Naudy Automatic Model interpretation (T43)

Top

The Naudy Automatic Model tool is a powerful interpretation tool for inferring the size, shape and position of magnetic sources using line data.

It can display:

- The inferred geological structures with a profile of the original TMI data, indicating similarity coefficients, size, shape and position.
- A profile of a field calculated from the inferred geological structures overlaid in the original TMI data, indicating the accuracy of the solutions.
- The extension to support Magnetic tensor gradients has been made during 2011. Very similar workflows are supported for this signal to the standard TMI case. The main difference lie in the location of anomalies, the determination of the magnetization vector direction, and the verification that the anomaly is caused by a 2D geology structure. This last point is particularly important, as a TMI signal cannot be expected to provide this information.

The tool can then optimise the inferred structures by repeatedly:

1. Calculating and comparing their field with the observed magnetic field, then
2. Adjusting their size, shape and position to improve the fit.

Naudy Automatic Model can save the results as an INTREPID or GEOSOFT points dataset, in a format for importing to the Potent modelling package, and joined into coherent sheet-like 3D dykes, described by “HOT-SPOT” structural data, for import into Geomodeller, the geologists editing and modelling package.

Naudy Automatic Model performs the modelling on data from single, selected traverse lines of magnetic surveys. On each line profile, the tool estimates the number, position, dip-angle, and depth to magnetic source. You can choose ‘body-type’ as an initial model parameter of the model (for example, dyke, step, flat prism). There are various options for estimating strike for the TMI case. Historically, the method assumed that the strike of any elongated body is oriented orthogonal to the traverse line. A trend-matching method can be used to estiamte the strike locally throughout the survey. Once you have a Full magnetic tensor signal, this is not a necessary step, as the signal conatins enough local curvatures of the field to un-ambiguously provide a strike direction for a 2D body.

Naudy Automatic Model concepts

Body See definition of 'Inferred geological structure' below.

Body strike Direction of an inferred geological structure when viewed from above.

Body dip The angle between the horizontal plane and the long axis of the inferred geological structure when viewed in a vertical section at right angles to **Body strike**.

Calculated field The magnetic field that would result from inferred geological structures.

Clearance field The height of the measurement sensor above the ground surface. This allows source depth estimates to be corrected for aircraft height above ground.

Depth increment factor (dif). INTREPID divides the depth range for calculating Naudy solutions into sections according to the depth increment factor. The height of the next depth section is dif times that of the section above. See Scanning for Naudy solutions.

Depth range The range of depths for finding and reporting Naudy solutions. INTREPID will not calculate solutions outside this range.

Depth range section See definition of 'Depth increment factor' above for an explanation.

Distance factor When resampling Naudy solutions INTREPID examines a region surrounding each solution. If the region contains one or more other solutions, INTREPID retains the solution with the lowest similarity coefficient and rejects the others. The X and Depth distance factors determine the size of the region examined around each solution. See Resampling the Naudy solutions.

Dyke See definition of 'Inferred geological structure' below.

Forward modelling Calculating a model by manually setting parameters and examining the calculated results (as opposed to inversion modelling which automatically adjusts the parameters so that the calculated result will closely match the observed data).

Geomodeller The sister product, Geomodeller, has a specially tailored import facility to directly receive, via a CSV file, the output from this tool, to rapidly help create a coherent 3D dyke swarm model. The interface is designed to allow you to do repeated trials, to best extract those geology bodies you wish to further interpret, in the context of creating a more holistic geology model.

HOT-SPOT Each solution for a 2D body along a profile, can be thought of as an intersection between the induced response from a geological body, as observed from an airborne sensor. The step of then collecting and sorting all the individual solutions into a set of coherent and consistent observation of a set of dykes, is sometimes called "Worming".

Inferred geological structure After calculating Naudy solutions for a line, INTREPID can infer the size and position of geological structures likely to cause the observed magnetic field.

Interpolation method When preparing line data for the Naudy Automatic Model, INTREPID resamples it so that the data points are evenly spaced along the line. This involves interpolating between existing data points. You can select the interpolation method. See Querying lines and setting resampling options.

Inversion process / Inversion modelling See the definition of 'Refining inferred

geological structures'

Naudy model The assemblage of inferred geological structures calculated for all or part of a dataset.

Naudy model point dataset Point dataset created by the Naudy Automatic Model tool containing Naudy model data.

Naudy sources / Naudy solutions An initial calculation derived from the observed magnetic field indicating potential sources for the field and leading to the calculation of inferred geological structures.

MTDYKE This is a companion tool, that can take the direct 'WORMS" output from Naudy, via the CSV file format, and predict on to a draped elevation grid, the forward model response of the dykes that have been found. In this case, each HOT_SPOT body is modelled. Alternatively, the tool also has provision for modelling the full 3D sheet-like triangulated description of the same dykes, as calculated by geomodeller.

Observed field TMI, Vertical derivative of TMI, Magnetic tensor gradients (FTMG) or Gravity tensor gradients (FTG) field recorded in the input line dataset for which you wish to calculate inferred geological structures.

Potent modelling package A software package published by PC Potentials which enables you to perform interactive magnetic and gravity forward and inversion modelling.

Refining inferred geological structures After calculating Naudy solutions and initial inferred geological structures, INTREPID can automatically refine them by repeatedly adjusting their size and position and comparing the calculated field with the observed field. See Refining inferred structures and optimising the calculated field.

Resampling mode (data preparation) When preparing line data for the Naudy Automatic Model, INTREPID resamples it so that the data points are evenly spaced along the line. You can specify whether the even spacing is geographic (based on the **X** and **Y** fields) or chronological (based on the **Fiducial** field). See Resampling mode for data preparation.

Resampling Naudy solutions After calculating Naudy solutions INTREPID selects the best ones for the next stage of the process. See Resampling the Naudy solutions.

Similarity coefficient A measure of the similarity between the calculated field of a Naudy solution and the observed field. Similarity coefficients range from 0 to 5, where 0 represents perfect match and 5 a low similarity. Method is based on scaled autocorrelation between the measured and calculated horizontal and vertical field components of the symmetric parts of the signal profiles. See Finding and resampling Naudy solutions.

Source region See definition of 'Distance factor' above for an explanation.

Threshold A cutoff value for similarity coefficients above which INTREPID will reject a Naudy solution during the resampling process. See Resampling the Naudy solutions

TMI See definition of 'Total magnetic intensity (TMI) field' below.

Total magnetic intensity (TMI) field INTREPID uses the total magnetic intensity field as the source of data for calculating the Naudy model. References to the Z field of the input dataset in this chapter mean its TMI field.

Trend points See definition of 'Spline gridding sample points' above.

Trend grid A grid created using the trend spline gridding process. See Specifying body strike for the Naudy model point dataset.

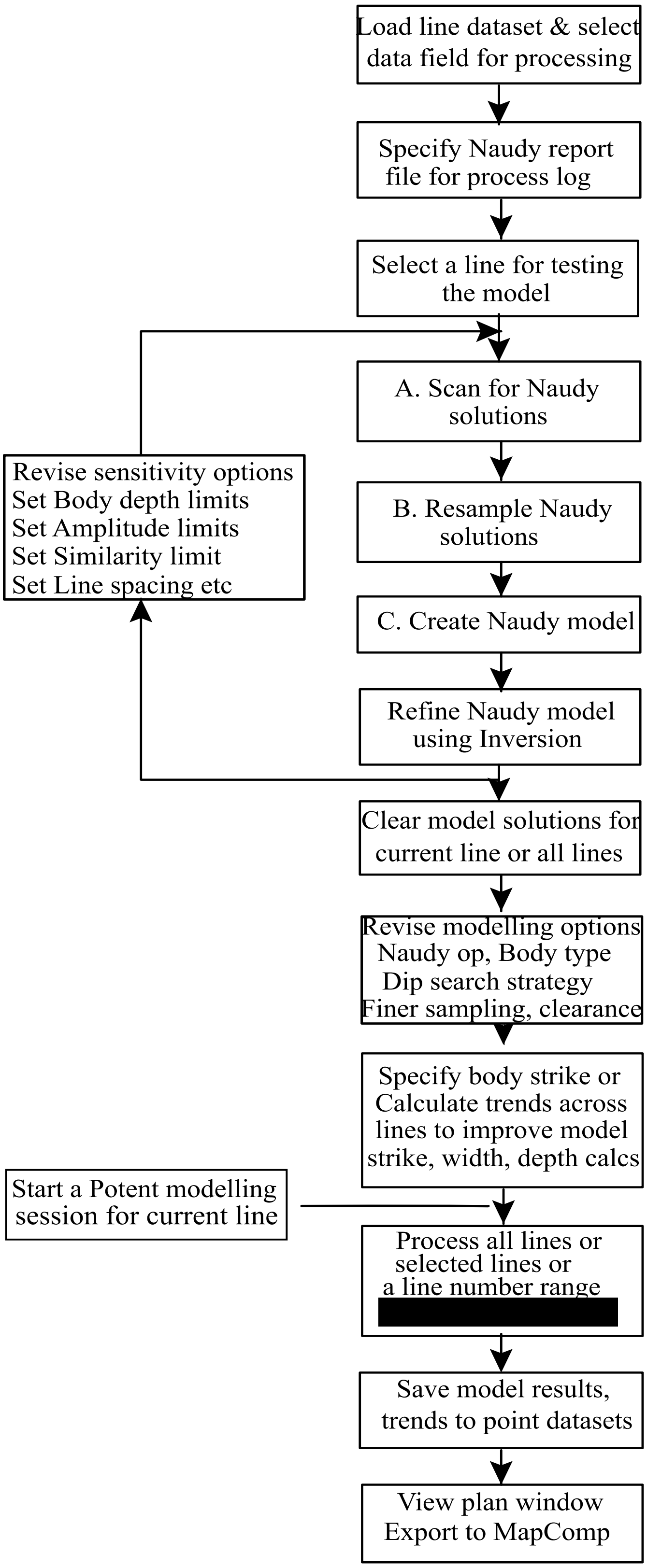
Vertical derivative of TMI INTREPID is also able to use the first vertical derivative of TMI as the source for calculating the Naudy model

Signal field In this chapter, references to the signal field of the input line dataset mean the TMI, Vertical derivative of TMI, magnetic tensor gradients or Gravity tensor gradients field. The field called **`Elevation`** in Naudy model point datasets contains the estimated Depth to the top of the source model after correction for Clearance if requested.

Using the Naudy Automatic Model tool

The flowchart shown here shows the essential steps in the Naudy Automatic Model process.

Naudy Automatic Model process

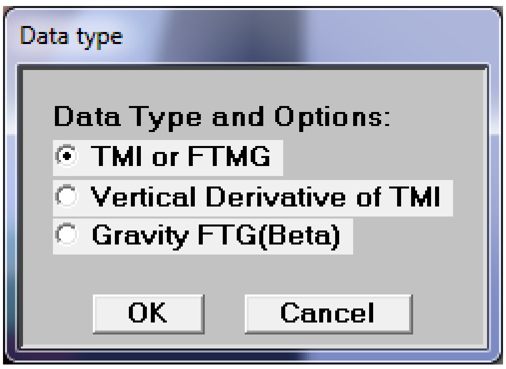


>> To use Naudy Automatic Model with the INTREPID graphic user interface

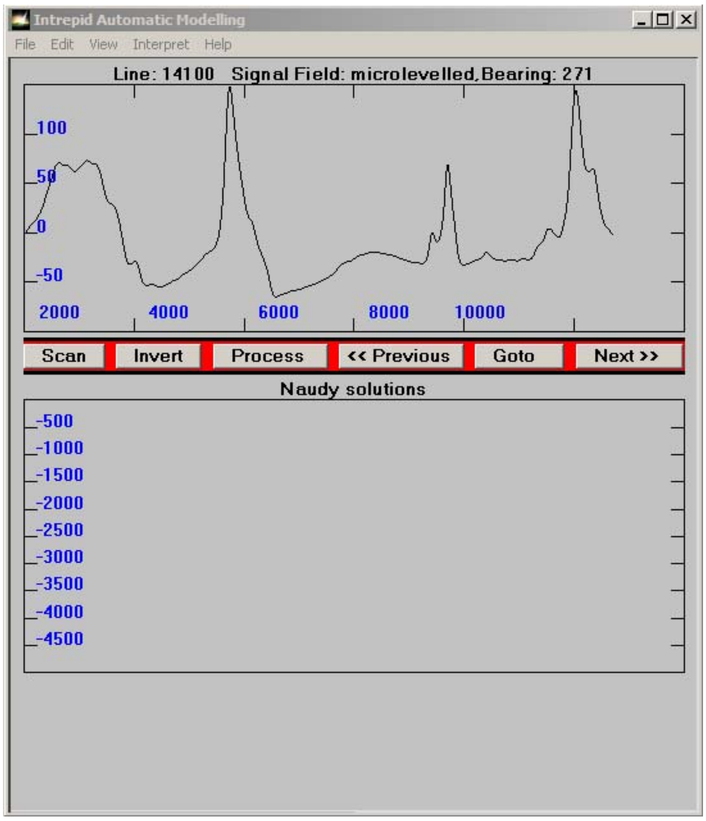
1 Choose Naudy Auto Model from the Interpretation menu in the Project Manager, or use the command **naudyd.exe**. INTREPID displays the Naudy Automatic Model Main window.

2 **File-> Load Options:** If you have previously prepared file specifications and parameter settings for Naudy Automatic Model, load the corresponding task specification file using Load Options from the File menu. (See Specifying input and output files for detailed instructions.) If all of the specifications are correct in this file, go to step 11. If you wish to modify any settings, carry out the following steps as required.

3 **File-> Load Line Dataset:** Specify the dataset and Data field for the Naudy Automatic Model. Use Load Line Dataset from the File menu. (See Specifying input and output files for detailed instructions.) Note the support for full tensor magnetic gradient signals. The extension to gravity gradient signal is also a very viable possibility, though the development and proving work is lagging.



INTREPID displays the first line from the dataset in the Naudy Automatic Model window.



4 **File-> Save Model As:** Once you have completed your modelling run you must specify a new output Naudy model point dataset to save your results using Save Model As from the File menu. This behaviour is new in Intrepid V4.2.2. In earlier versions the model results file was specified at the start of modelling operations

Or

It is no longer possible to load an existing Naudy model point dataset which you wish to view, extend or modify in INTREPID V4.2.2. It is available again in V5.0

5 **File-> Specify Report:** Before proceeding with a modelling session it is recommended that the user specify a report file name for saving the progressive results of a session. Naudy uses a default file name and this will is appended to from session to session making it difficult to track results and settings at a later time.

6 **File->Export Dykes to Geomodeller:** You must have saved the model first. Options are presented to allow you to select and influence the number, length, sampling frequency etc. of a what amounts to a geophysics derived set of strucural geology observations of any dykes present in the survey.

Note: During the Naudy Automatic Model session you can at any time:

- View line statistics,
- Change line resampling options,
- Zoom the display in and out, and
- Display different line profiles.
- **View-> Plan Window:** Display the current Naudy model in a plan view window.

(See Navigating the profile and model display, Querying lines and setting resampling options and Plan view for detailed instructions.)

- Specify the search complexity for the process and whether you wish to refine the inferred geological structures using the inversion process. (See Search complexity and refinement options for detailed instructions.)
- Start a Potent 4 modelling session from the **Interpret** menu for the currently displayed line's model.
- Save the existing Naudy model point dataset at any point in the modelling process. Reloading model point datasets is no longer possible in INTREPID V4.2.2. (See Specifying input and output files for detailed instructions.)

7 **Interpret-> Earths Magnetic Field:** Specify the Earth's core magnetic field data for the survey if you wish to override the automatic calculation from the IGRF model. See Specifying the Earth's core magnetic field data for detailed instructions.

8 **Interpret->Model Parameters:** Select the required parameters from the Advanced Model Options. You can remove the Clearance from the estimated body depths and specify the search complexity for the process and whether you wish to refine the inferred geological structures using the inversion process. (See Search complexity and refinement options for detailed instructions.)

9 **Interpret-> Sensitivity Test Parameters:** Display the Model Parameters and Testing Options dialog box

Specify the parameters

A. Scan for solutions

B. Resample the Naudy solutions

C. Create the Model and finally

Opt. Refine the Model using Inversion.

Repeat the search and resample with different parameters as required. (See Finding and resampling Naudy solutions for instructions) INTREPID displays graphically the similarity coefficients and position of Naudy solutions.

10 Specify the line spacing of the input dataset and create the Naudy model for the current line, calculating shape, size and position of inferred geological structures and the initial calculated field (See Creating the model: inferred structures and initial calculated field for instructions). INTREPID displays the inferred geological structures.

11 If required, specify the number of inversion iterations, then refine the inferred geological structures and optimise the fit of the calculated field with the observed field. See Refining inferred structures and optimising the calculated field for instructions.

12 Repeat steps 7-10 as required until you are satisfied with the results.

13 **Interpret->Model Parameters:** For regularly spaced line data specify Body Strike Options (Calculate trends) to provide estimated body strike information for the inferred structures. See Specifying body strike for the Naudy model point dataset for instructions.Apply the process to some or all of the dataset lines using Process from the Naudy Automatic Model window. See Calculating the model for all or part of the dataset for instructions.

14 If you wish to record the specifications for this process in a **`.job`** file in order to repeat a similar task later or for some other reason, use Save Options from the file menu. See Displaying options and using task specification files for detailed instructions.

15 **File-> Save Model As:** Once you have completed your modelling run you must specify a new output Naudy model point dataset to save your results using Save Model As from the File menu.

16 If you wish to adjust the process and apply it again, repeat steps 6–12 (using the same dataset and TMI field).

17 **Edit->Clear Model for All Lines:** Alternatively you can clear the model for the the current line and continue or clear the model for all lines and start again with a new set of parameters before saving your model results.

18 **File-> Quit:** To exit from Naudy Automatic Model, choose Quit from the File menu. If you have not saved your model results you will be prompted with a summary of the number of results saved and be given the opportunity to Cancel, Save the results and then Quit.

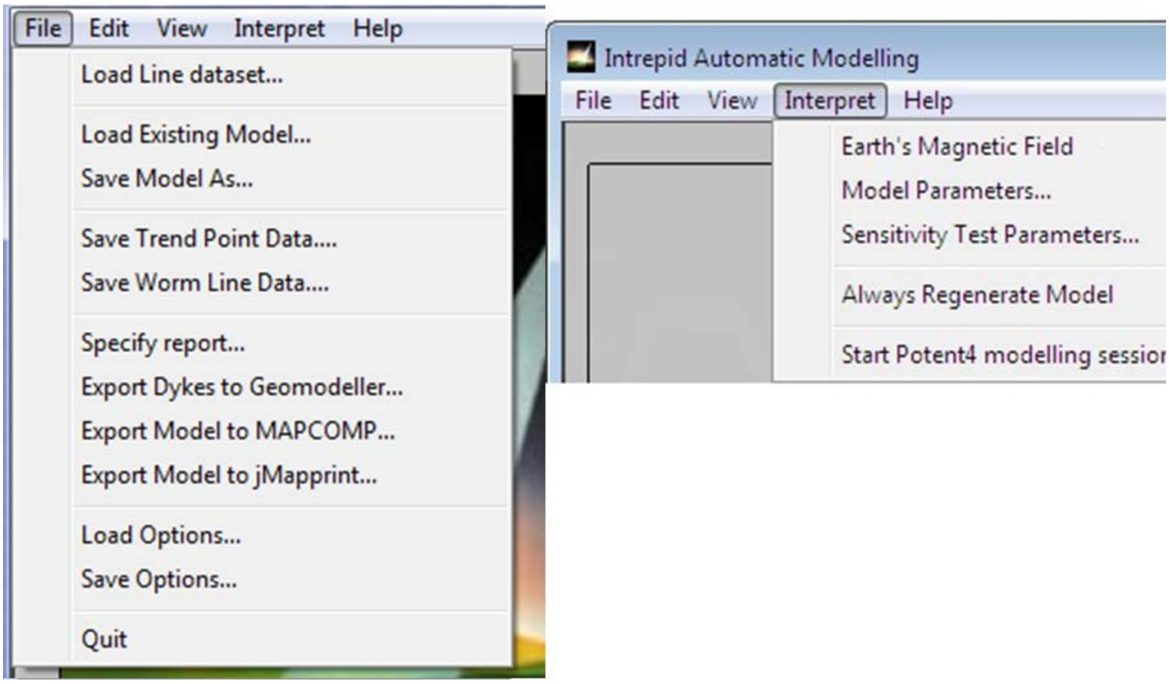
You can execute Naudy Automatic Model as a batch task using a task specification (`.job`) file that you have previously prepared. See Displaying options and using task specification files for details.

Specifying input and output files

To use Naudy Automatic Model,

- **File-> Load Line Dataset:** You will need to specify the line dataset to be loaded and the database field to be processed.
- **File-> Save Model As:**When you have finished your modelling session you must specify a Naudy model point dataset for saving the calculation results.
- **File-> Save Trend Point Data:** You can also save trend point data calculated during a modelling session to an Intrepid or Geosoft database.
- **File-> Save Worm Line Data:** Worm line data generated from the above trend calculations can also be saved. This is not to be confused with the next, recetly released feature.
- **File->Export Dykes to Geomodeller:** The full model solution set is resorted, and searched, to form 3D dykes that link the individual HOT-SPOT solutions,that are spatially coherent. Susceptibilities, RMS error estimates, thickness, dip and strike are part of the solution set. A set of linear summary dykes is laso available as a seperate CSV file.
- **File-> Specify Report:** Before proceeding with a modelling session it is recommended that the user specify a report file name for saving the progressive results of a session. Naudy uses a default file name and this will is appended to from session to session making it difficult to track results and settings at a later time.

- Choose the options as required from the File or Interpret menu. The illustrations below show the file menu before and after loading a line dataset.



In each case INTREPID displays an Open or Save As dialog box. Use the directory and file selector to locate or specify the file you require. (See "Specifying input and output files" in Introduction to INTREPID (R02) for information about specifying files).

INTREPID may need to obtain information from the dataset aliases. If you select geographic or chronological resampling (See Resampling mode for data preparation), the dataset must have aliases identifying appropriate field names.

Alias	Field
For geographic resampling:	
X	X coordinate (geographic location)
Y	Y coordinate (geographic location)
For chronological resampling:	
Fiducial	Fiducial count

See "Vector dataset field aliases" in INTREPID database, file and data structures (R05) for more information about aliases.

Summary of file operations

File menu options

Load Lines Use this option to specify the line dataset for modelling. INTREPID will prompt you to specify the line dataset, the magnetic or gravity field to be modelled. The resampling mode can be set by Right clicking in the top profile window once the dataset is loaded. (See Resampling mode for data preparation).

If you have selected geographic resampling and there are no valid **X** and **Y** aliases specifying the geographic location fields INTREPID will also display Open dialog boxes for you to specify them.

INTREPID will then open the dataset and display the profile of the first line in the Naudy Automatic Model main window. For a tensor signal, the tensoir must have been formed in the database as a proper tensor signal object. Check via the jFmanager TAB for its data type. If properly formed, once you have chosen the magnetic tensor field, the 6 components of the tensor are shown in the top panel, in an analogous manner to the TMI. Support for FTG or full tensor gravity gradiometry profile data is still in its infancy, as this Naudy method has traditionally been associated with magnetics. The quality and signal content in modern FTG profile data, does however, allow for an extension of this tool to support FTG data. INTREPID saves model data to a temporary dataset whenever it performs a model calculation operation. Saving the model results to a database file of your own is not required until the end of a session. See Calculating the model for all or part of the dataset and Saving the model as a point dataset for details.

Load Existing Model You can not load an existing Naudy model point dataset for continuing work in version 4.5, but you can at V5.0 of Intrepid.

Save Model As Use this to save your current results Naudy model point dataset.

Load Options If you wish to use an existing task specification file to specify the Naudy Automatic Model process, use this option to select the task specification file required. INTREPID will load the file and use its contents to set all of the parameters for the Naudy Automatic Model process. (See Displaying options and using task specification files for more information).

Save Options If you wish to save the current Naudy Automatic Model file specifications and parameter settings as a task specification file, use this option to specify the filename and save the file. (See Displaying options and using task specification files for more information).

File operations from the Interpret menu

Load Trend Point Data Use this option to load a previously saved trends dataset to assist with calculating the strike of the inferred geological structures. See Specifying body strike for the Naudy model point dataset for details.

Resampling mode for data preparation

The Naudy Automatic Model tool requires data points in the line dataset to be evenly distributed with no internal gaps. When INTREPID loads a line dataset it immediately resamples if this is not the case.

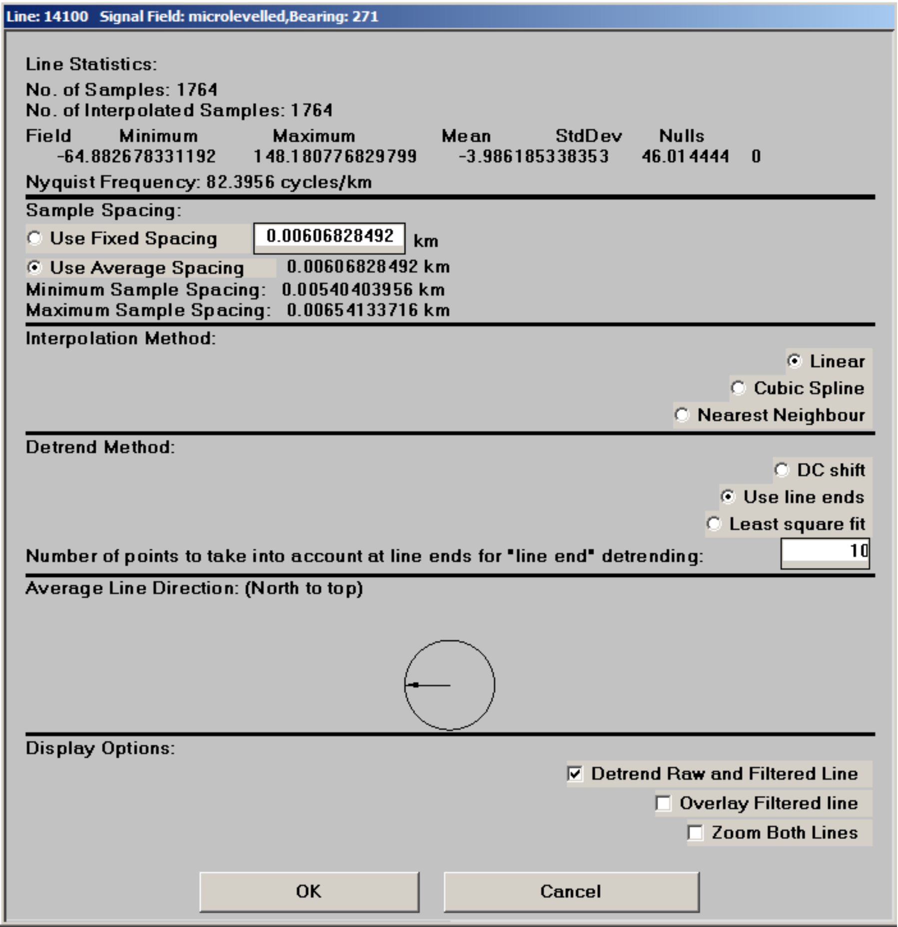
INTREPID replaces ***null***s using the cubic spline, linear or nearest neighbour interpolation method. The default method is linear interpolation. You can change the method using the Current Line Statistics and Options dialog box (See Querying lines and setting resampling options for instructions).

The Naudy Automatic Model tool performs further resampling and interpolation of this prepared data using its own methods as necessary for its process.

You can select one of three resampling modes. For two of these modes you need certain aliases as described below.

>> *To select the resampling mode*

1 Load a line dataset for modeling as described above. Right click in the upper profile panel and INTREPID displays the Resampling Mode dialog box.



2 Select the resampling mode (Linear, Cubic Spline, Nearest Neighbour) by toggling the required option.

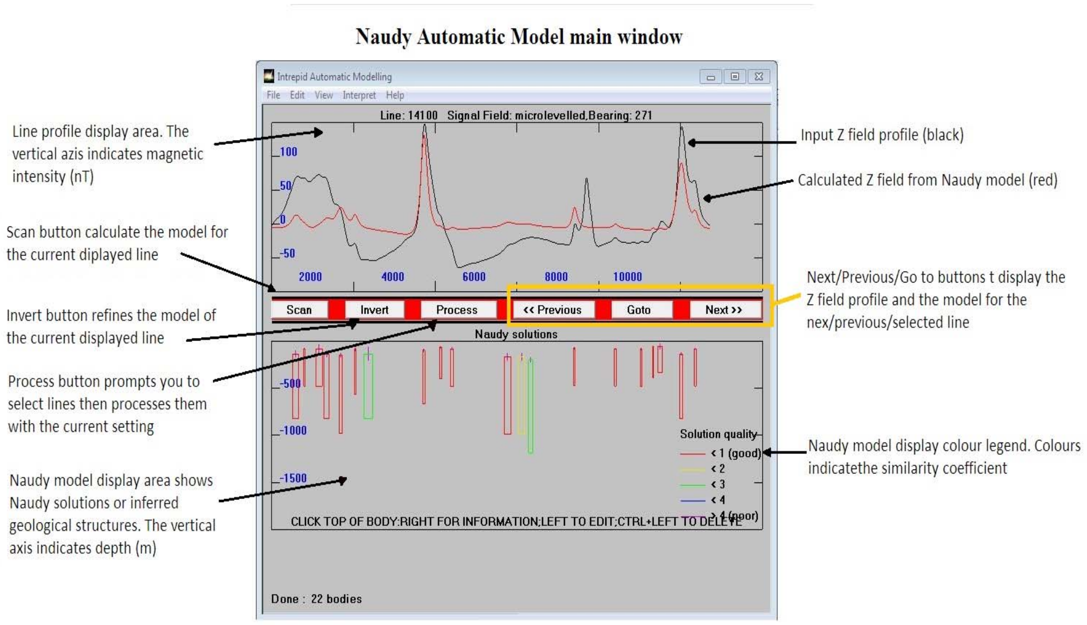
3 **Geographic ('Geo-Located')** INTREPID examines the X and Y fields of the dataset and resamples the data so that it is distributed evenly with respect to distance. If you choose this option your line dataset must have properly defined **X** and **Y** aliases.

Use Fixed Spacing Use this text box to specify the resampling interval in kms

. **Use Average Spacing** (Default) Use this text box to use the average sampling interval in kms

The Naudy Automatic Model main window

The following diagram summarises the components of the Naudy Automatic Model main window.



Upper plot

The black line shows the measured' two dimensional magnetic profile for the given traverse line. The red line shows the 'predicted' magnetic profile that would result from the Naudy-derived solution (the magnetic bodies shown in the lower plot), that is, the optimal number, position, dip-angle and depth of magnetic bodies pre-described either as 'dyke-shapes' or 'step-shapes'.

Lower plot

The lower plot contains the Naudy solutions. It illustrates the optimal number, position, dip-angle and depth of magnetic bodies required to give the best possible match of 'measured' to 'predicted' magnetic intensity signal for the given traverse line.

The bottom right-hand legend indicates goodness of fit (solution quality), for each individual 'body', by means of colour-coding. You can easily see a measure of overall solution quality for the traverse line by comparing the black and red profiles in the upper plot.

Horizontal axis

The horizontal axis on both the upper and lower plots represents the distance in metres from the start of the traverse line.

Vertical axis in the upper plot

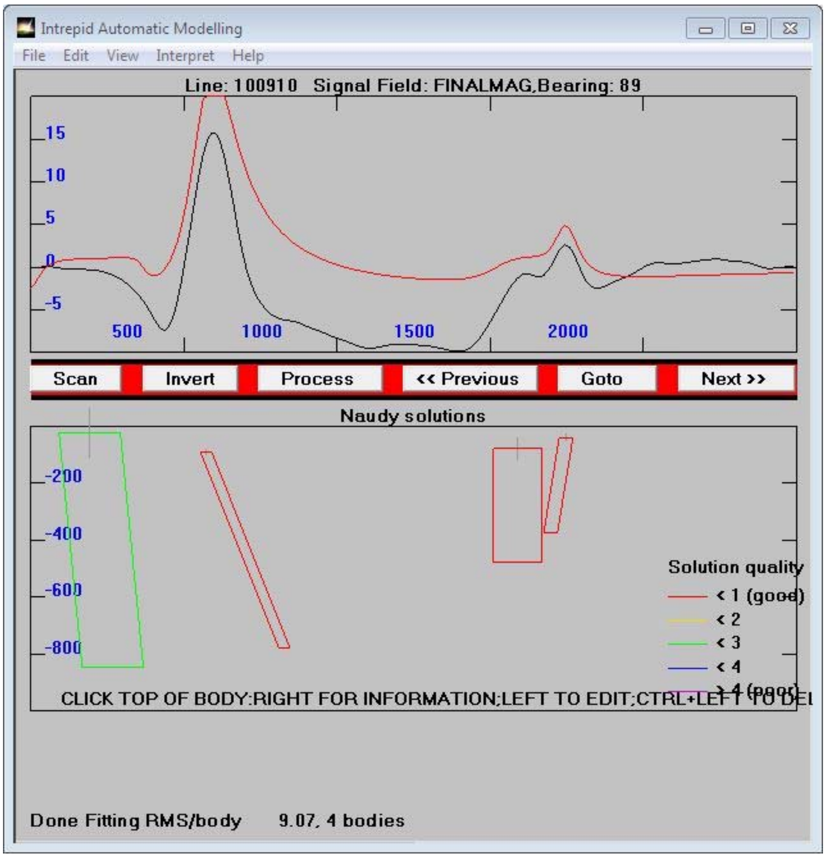
The vertical axis in the upper plot represents the magnetisation in nT. Notice that the data is de-trended as it is 'relative change' in magnetic signal that is most important for determining location of magnetic bodies.

Vertical axis in the lower plot

The vertical scale in the lower plot represents depth (in metres) below observation height or ground level if the Remove Clearance option is chosen. The body 'depth to top' is corrected for aircraft clearance (RADALT) in this case. The cross on top of each modelled body directly marks the 'top of the magnetic source'. The size of this cross corresponds directly to the slenderness ratio of the modelled body.

Inferred geological structure colours

The Naudy model display colour indicates the inferred geological structure's similarity coefficient. Red indicates a high quality solution (less than 2). Blue indicates medium quality (between 2 and 3). The legend in the model display area is a guide to these colours.



See Finding and resampling Naudy solutions for details about the similarity coefficient.

Navigating the profile and model display

In the upper data display section the Naudy Automatic Model window shows (in black) a profile of the observed field for a single line and (in red) the current calculated field from the current model. These profiles are

- The original input data field and
- The current calculated field.

The horizontal scales of the input or observed field and calculated field are synchronised, so that you can compare corresponding values for any data point.

You can navigate the dataset display in the following ways.

- Viewing the profile of any line in the dataset;
- Zooming in on any section of a profile or model solution.

Selecting a line you wish to view

When you first load a line dataset, INTREPID displays the input data for the first line in the dataset. You can display other lines using the Next, Previous and Go To command buttons.

The Naudy Automatic Model automatically sorts line numbers into ascending order, irrespective of their actual order in the dataset.

When you view a line in the Naudy Automatic Model main window

- If the option Always Regenerate Model in the Interpret menu is turned on (Default) then INTREPID always recalculates and displays the inferred geological structures and calculated field even if a prior model exists for that line
- If the option Always Regenerate Model in the Interpret menu is turned off and a model exists for the line, INTREPID will display its inferred geological structures and calculated field.

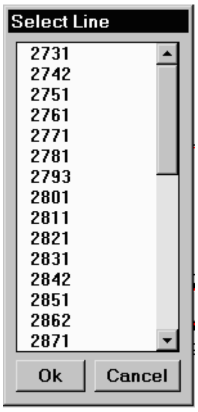
See Viewing and recalculating individual lines during the specification process for details about model recalculation for individual lines.

See Calculating the model for all or part of the dataset for further information about obtaining an up to date model for a desired set of lines.

>> *To view the Next or Previous line (according to line number)*

1 If the Automatic Modelling Options and Testing dialog box is open, close it (Choose Accept or Cancel).

2 Use Next or Previous from the Naudy Automatic Model window to view the next or previous line respectively.



>> *To view the line of your choice*

1 If the Automatic Modelling Options and Testing dialog box is open, close it (Choose Accept or Cancel).

2 Choose Go To in the Naudy Automatic Model window. INTREPID displays the Select Line dialog box.

3 Select (click) the number of the line you wish to view, then choose OK. INTREPID displays the line.

Enlarging and reducing (zooming) the profile display

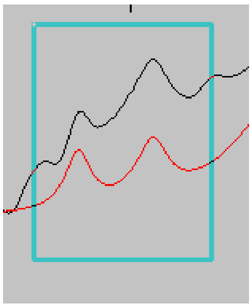
You can enlarge the profile display (zoom in) to display only part of a line profile, then zoom out again when you have finished.

When you zoom in, INTREPID will

- Always synchronise the horizontal scale of the two data areas,
- Set the vertical scale of the field profile according to the height of the zoom area you specified and the profiles included in the selection,
- Set the vertical scale of the inferred geological structures to match their horizontal scale and maintain the original aspect ratio.

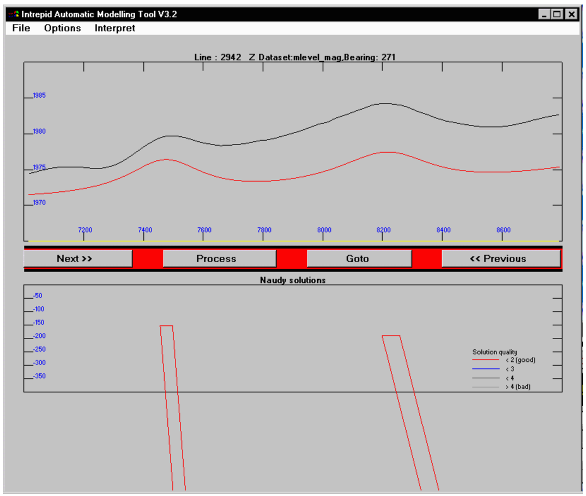
>> *To zoom in on an area of the display*

1 Move the mouse pointer to one corner of the region that you wish to enlarge. Hold down the left button and drag to the diagonally opposite corner of the region. INTREPID displays a light blue frame defining the region you select.



2 Release the mouse button.

INTREPID will enlarge the display to show only those points you selected.



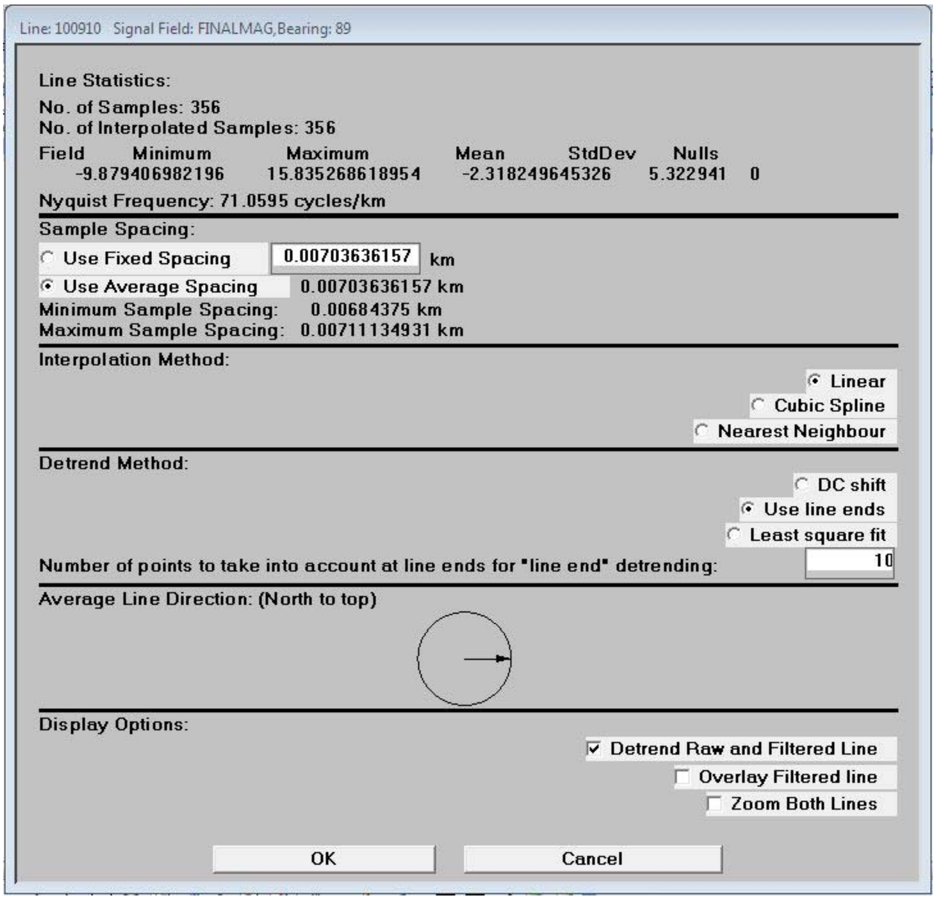
>> *To zoom out*

Double click anywhere in the zoomed display (left mouse button).

Querying lines and setting resampling options

You can display information about the current line and select a range of options for processing it, as described in this section.

>> To query the current line and select options



1 Right button click the line display. INTREPID displays the Current Line Statistics and Options dialog box.

2 View the statistics and select options as required, then choose Accept.

No of Samples The number of data points in the current line that have values for the current observed field.

No of Interpolated Samples The number of data points in the current line derived by resampling and used for the Naudy Automatic Model calculations.

Max Signal Value, Min Signal Value, Mean Signal Value, Signal StdDev, Nulls INTREPID displays basic observed field statistics for the current line.

Nyquist Frequency The highest frequency possible in the spectral domain given the current resampling rate1.

Sample Spacing (*Geographic resampling only*) This parameter corresponds to the distance between interpolated samples. You can modify this to increase or decrease the resampling rate and thus the Nyquist frequency[1] or use the Average Spacing (the maximum and minimum values of the sample spacing are reported to the user)

Interpolation Method Use these options to specify Linear, Cubic Spline, Nearest Neighbours interpolation for the resampling data preparation process (See Resampling mode for data preparation).

Cubic Spline interpolation uses a curve through a number of original data points on each side of the position for the resampled point.

Nearest neighbours uses a 'triangulation' technique to determine the value for a position based on the values at neighbouring original data points.

Detrend Method INTREPID automatically detrends the input data field before displaying and modelling it in Naudy. The user can choose which method to use when detrending.

Average Line Direction INTREPID displays the average bearing (North towards the top as in a compass) of the current line in this diagram.

Detrend Raw and Filtered Line This check box does not apply to this tool. Detrending of the input field is always on

Overlay Filtered Line This check box does not apply to this tool.

Zoom both lines This check box does not operate in this tool. All zoom operations synchronise both display areas.

1. In the current version of INTREPID, this statistic is available only if you are using geographic resampling. If you require the corresponding statistic for chronological resampling, contact our technical support service. See Resampling mode for data preparation for further details.

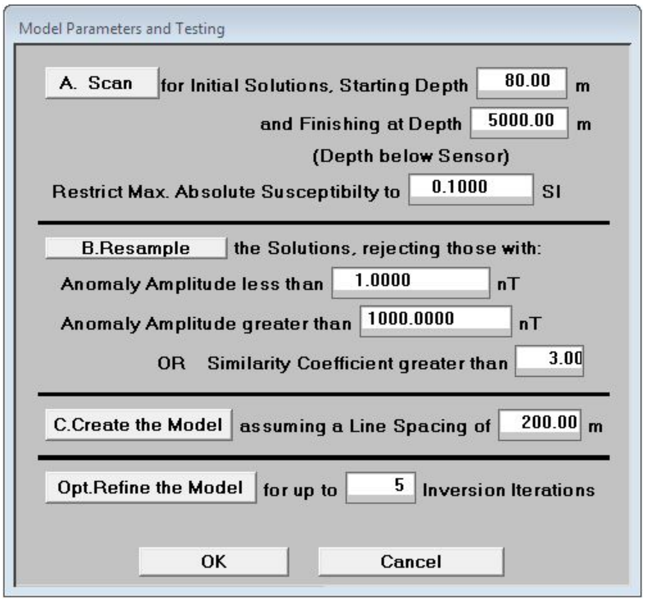
Plan view

You can display a plan view of the current model. It shows all lines for which the model exists, with the inferred geological structures superimposed on the lines.

>> *To display the plan view*

1. If you will only be using Similarity colour mode where colours represent the similarity coefficient of the inferred geological structures, go to step 4.
2. Inspect the model for some lines to determine the range of depths of the inferred geological structures.
3. If the Model Parameters and Testing dialog box is not open, choose Sensitivity Test Parameters.. from the Interpret menu to display it.

   For Depth colour mode display, INTREPID will assign the range of colours to depths between 0 and the Finishing at Depth value specified here. This is likely to be a smaller number than you use as a maximum for calculating the Naudy solutions. Specify the Finishing at Depth value required, then choose OK.



   See 'The range of depth values in the legend' below for further explanation.

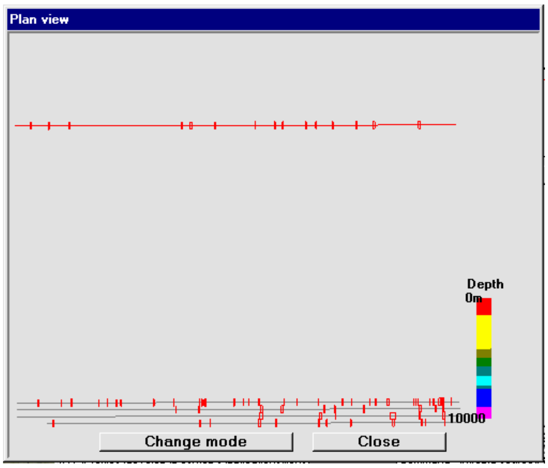
4. Choose Plan Window from the Options menu.

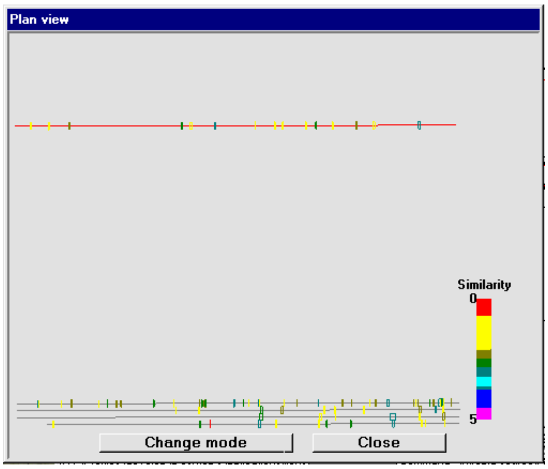
   INTREPID displays the Plan View window.

5. Choose Change Mode to switch between the Depth, Similarity or Trend colour displays as required. Trend is only available if the Calculate Trends option is turned on in Model Parameters
6. When you have finished with the Plan View, choose Close.

7 If you will be calculating further Naudy solutions, return the Finishing at Depth in the Automatic Modelling Options and Testing dialog box to an appropriate value for this process.

The Plan View window shows lines for which the current model exists. The inferred geological structures are coloured rectangles superimposed on the lines.





The rectangle dimension perpendicular to the lines simply indicates the line spacing, allowing you to identify the line from which the solution originates.

The rectangle dimension parallel to the lines indicates the widths of the inferred geological structures, and corresponds to the width as displayed in the profiles in the Naudy Automatic Model main window.

The colour of the rectangle either corresponds to the depth of the inferred geological structure or the similarity coefficient. The colour legend in the lower right corner has a label indicating the current display mode.

The range of depth values in the legend (**Depth colour mode**) The maximum value corresponds to the current Finishing at Depth setting in the Scan section of the Automatic Modelling Options and Testing dialog box. It does not necessarily correspond to the value of this parameter at the time the model was calculated. See Scanning for Naudy solutions for details about this parameter. See 'Depth' in Finding and resampling Naudy solutions for details about the depth result.

The similarity coefficient values in the legend (**Similarity colour mode**) correspond to the possible values for this calculated result. See Finding and resampling Naudy solutions for details about this result.

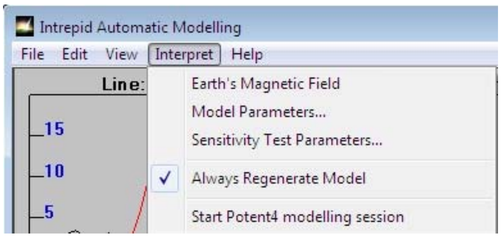
Change mode Choose this to switch between the Depth, Similarity or Trend colour displays.

Close Choose this to close the Plan View window.

Specifying the modelling process

This section describes how to specify the Naudy Automatic Model process. During the specification process you will calculate and view the results for your specifications for individual lines as required for optimising the specifications. This calculating and viewing is intended only to assist you with the specifications. When you are ready to calculate the model for the dataset, you will use the Process button in the Naudy Automatic Model window. See Calculating the model for all or part of the dataset for instructions about this next step.

You can specify the Naudy Automatic Model using options from the Interpret menus.



Here is an outline of the specification process. The following sections give detailed instructions for each step.

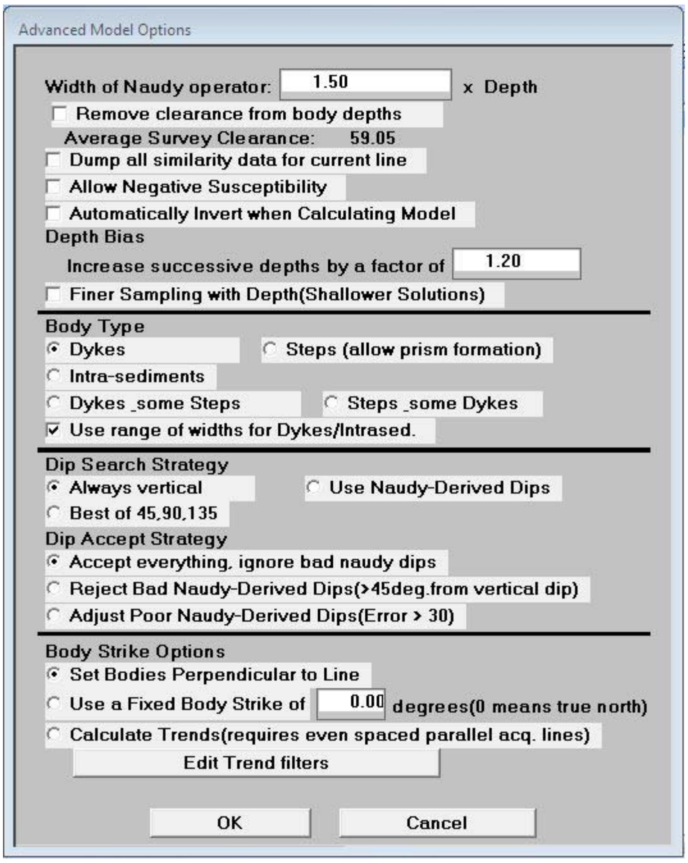
>> To specify the Naudy Automatic Model process

1 Specify the Earth's core magnetic field if you wish to override the automatic calculation. (See Specifying the Earths core magnetic field data).

2 You will firstly develop and test the model using individual lines. Display a suitable line for this process. You can display different lines at any time during specification and testing if required. Ignore any default model that INTREPID displays for the line when it first appears.

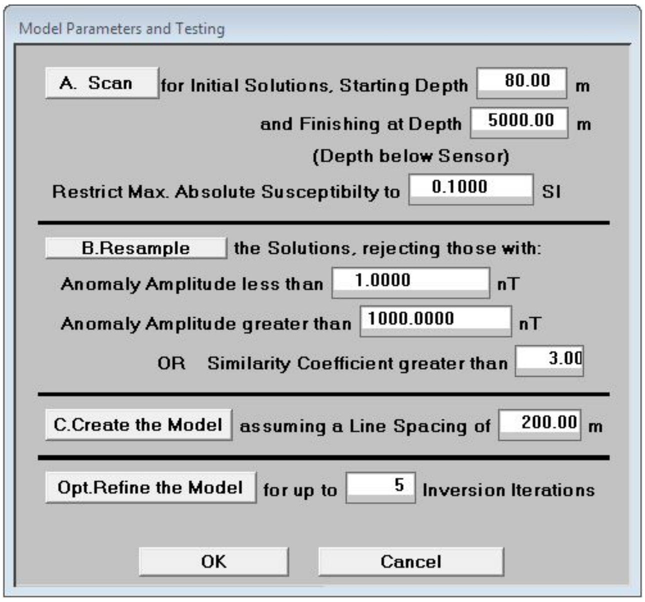
3 Select **Interpret-> Model Parameters** and set the Advanced Model options specified in the following dialog.. These options control the way your model search will be targeted to the geological/geophysical environment of your survey and how solutions will be further filtered, refined and reported. For TMI aeromagnetic surveys, we recommend

1. Dykes
2. Use Naudy-derived dips (the aspect that is most susceptible to noise)
3. adjust poor dips
4. calculate trends (precompute the body strikes - very important)
5. No negative susceptibility



4 Select **Interpret -> Sensitivity Test Parameters** and the Model Parameters and Testing dialog box. It will remain open while you develop and test the model. You will use it for steps 4–7.

- View different lines of the dataset and zoom in and out. INTREPID will automatically calculate and refine the model with the current settings for any line that you display. You need to close the the Modelling Parameters and Testing dialog box before viewing different lines.



5 Specify and search for Naudy solutions.

6 Specify the resampling criteria and resample the Naudy solutions.

7 Create the model for the line. INTREPID displays initial inferred geological structures and the calculated field profile.

8 Refine the model by adjusting the inferred geological structures.

9 Choose OK to close the **Model Parameters and Testing** (**Sensitivity Test Parameters**) dialog box.

10 If required, return to the **Advanced Modelling Options** (**Model Parameters**) dialog to revise the search target style, complexity and solution refinement/ filtering options for processing the whole dataset ie Calculate trends, remove clearance from estimated depths etc.

The next step is to calculate and refine the model for some or all lines from the dataset. See Calculating the model for all or part of the dataset for instructions.

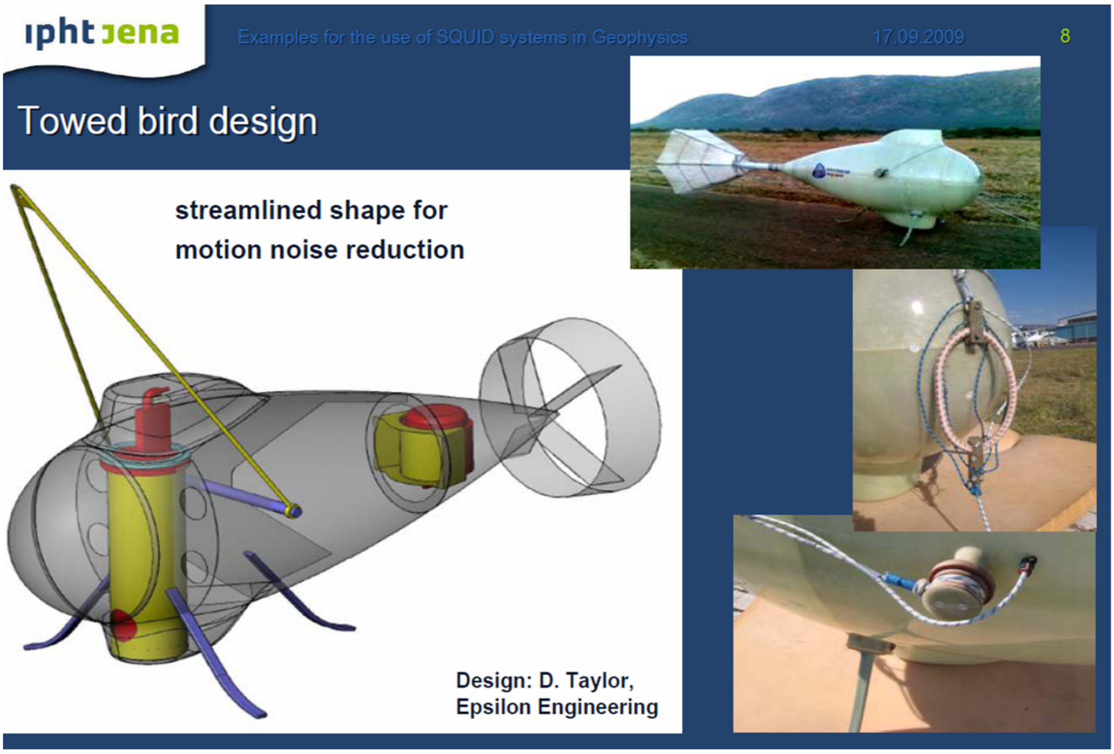
Remanence

Remanence is also a big subject, so for TMI, a negative susceptibility is a poor-man’s method of indicating dykes that could have reversed vector components to the IGRF.

The big interest however comes with FTGM, or magnetic tensor gradients. Suddenly, it is no longer possible to fit a simple DYKE to every anomaly, if in fact the anomaly is caused by something that is not inherently 2D in nature. (With TMI, you can always find a 2D solution to every anomaly.) Further, once there is a 2D body, the tensor gradient components very clearly also carry a great deal of rotational information about the induced magnetic response vector, so a new algorithm is delivered here

that, at step 2, searches for a magnetic vector's 2 primary orientation measures, inclination and declination, that best explains the tensor gradient component distribution. Following this, a bounded, non-linear inversion of the geometry factors and the susceptibility is undertaken to improve the estimation of the DYKE HOT SPOT, to best fit the observed field.

This is another first for potential field geophysics from INTREPID. Horst Holstein has delivered most of the required modelling and inversion theroy here. Anglo/ DeBeers have also pushed the developement of the magnetic Tensor survey technique to make it quite viable, and now best magnetic survey practice.



Viewing and recalculating individual lines during the specification process

You can view different lines during the specification process. Before changing to another line you must close the **Model Parameters and Testing** dialog box. INTREPID displays inferred geological structures and calculated field for the newly displayed line according to the following rules.

When you view a different line:

- If you display a line for which no model exists and the Always Regenerate Model option in the Interpret menu is turned on, INTREPID will immediately calculate and display the model for the line using the current settings.

  INTREPID will perform the model calculation for the new line according to the parameters you have set in both the **Model Parameters and Testing** and **Advanced Modelling Options** dialog boxes. The parameters controlling the process include the complexity of the search and whether to perform model refinement. See Search complexity and refinement options for details.
- If you display a line for which a model exists and the Always Regenerate Model option in the Interpret menu is turned off, INTREPID displays the existing model for the line. If you wish to recalculate the model using the current specifications, simply choose as many buttons from the sequence 'Scan, Resample, Create the Model and Refine the Model' as required to update the calculations for the line.

To continue model specification with the newly displayed line, simply display the **Model Parameters and Testing** dialog box and continue.

See Selecting a line you wish to view for details about displaying different lines.

At any stage during or after the specification process you can transfer the current line to the Potent modelling software by selecting **Interpret->Start Potent 4 Modelling Session** from the main menu bar.

Specifying the Earth's core magnetic field data

The Naudy Automatic Model tool requires an Earth's core magnetic field data for use in its calculations. It requires the data for a horizontal and vertical component calculation and for producing the calculated field.

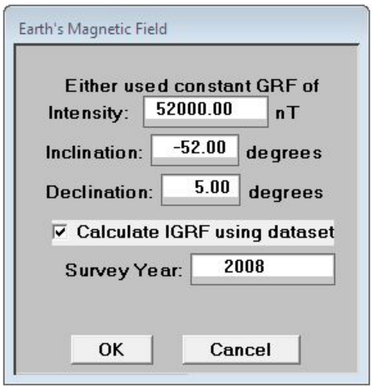
INTREPID normally calculates the Earth's core magnetic field data from the IGRF model using the survey date 1 January 1980. We regard this as sufficiently accurate for the purposes of the Naudy Automatic Model tool.

You can override this automatic calculation if required and enter your own field intensity, inclination and declination.

See The geomagnetic reference field in INTREPID (R15) for a discussion of this topic.

>> To specify the Earth's core magnetic field data for this Naudy Automatic Model session

1 Choose **Earth's Magnetic Field** from the **Interpret** menu. INTREPID displays the Set Field Components dialog box.



2 Specify the Field Strength (intensity), Declination and Inclination.

3 Turn off the Calculate IGRF using Dataset check box.

4 Choose OK.

>> To automatically calculate the Earth's core magnetic field data from the dataset

(This is the default state for the tool)

1 Choose **Earth's Magnetic Field** from the Interpret menu. INTREPID displays the Set Field Components dialog box.

2 Turn on the Calculate from Dataset check box.

3 Choose Accept.

Finding and resampling Naudy solutions

>> To calculate Naudy solutions for a line, including similarity coefficient, position and depth

1 Specify the depth range to search, then calculate the Naudy solutions. You can also specify advanced options: the width of the Naudy operator, the depth increment, and the body strike. See Scanning for Naudy solutions for details.

2 Resample and thin out the Naudy solutions:

- Specifying a maximum similarity coefficient and minimum amplitude for inclusion, and
- Selecting the solution with the lowest similarity coefficient if several solutions occur close to each other.

See Resampling the Naudy solutions for details.

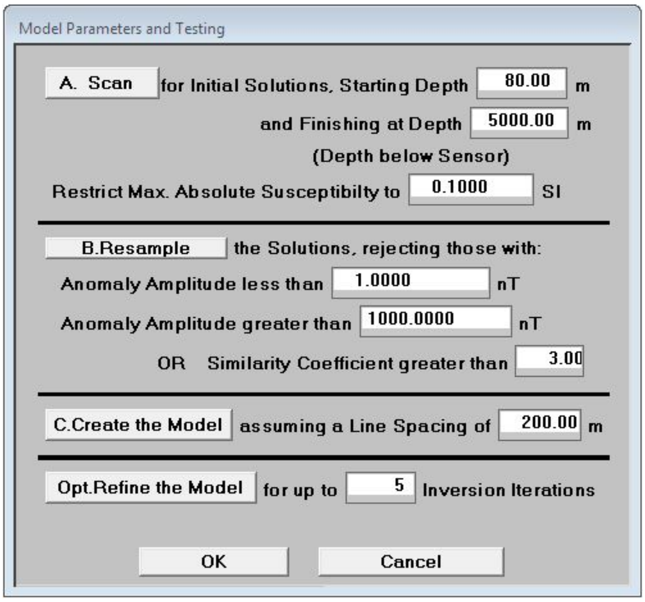
Similarity coefficient This is a measure of the similarity between the calculated field of a Naudy solution and the observed field. Similarity coefficients range from 0 to 5, where 0 represents a good match and 5 represents zero similarity. For Naudy solutions used to calculate inferred geological structures, INTREPID will save this data in the Naudy model point dataset as field **`Similarity`**.

Position The scanning process calculates the location of Naudy solutions. For Naudy solutions used to calculate inferred geological structures, INTREPID will save this data in the Naudy model point dataset as fields **`X`** and **`Y`**.

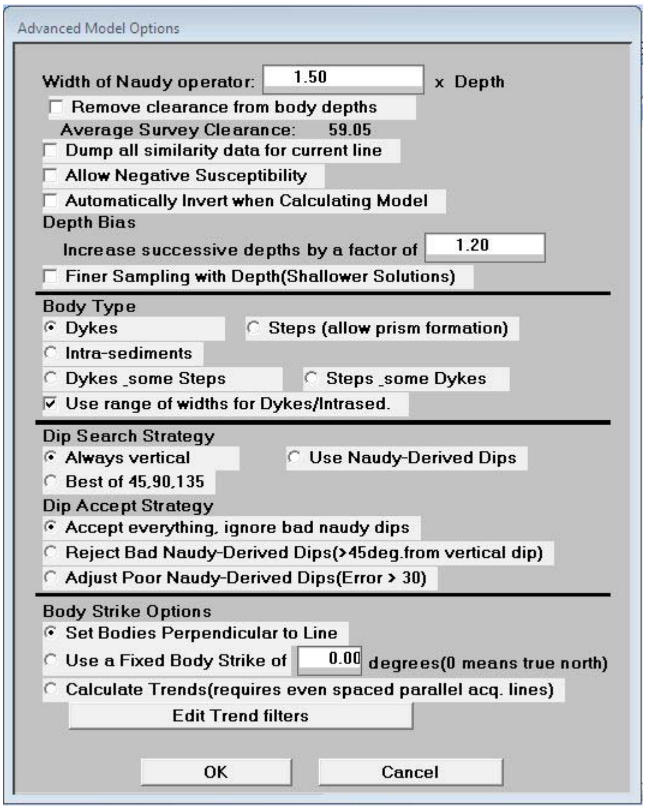
Depth The scanning process calculates the depth below the data acquisition height of Naudy solutions or below the ground if the Clearance option is selected and the dataset contains a Clearance field with the alias correctly set. For Naudy solutions used to calculate inferred geological structures, INTREPID will save this data in the Naudy model point dataset as field **`Z`**.

Scanning and Resampling dialog box options

Use the upper two sections of the **Model Parameters and Testing** dialog box to specify and test this part of the process.

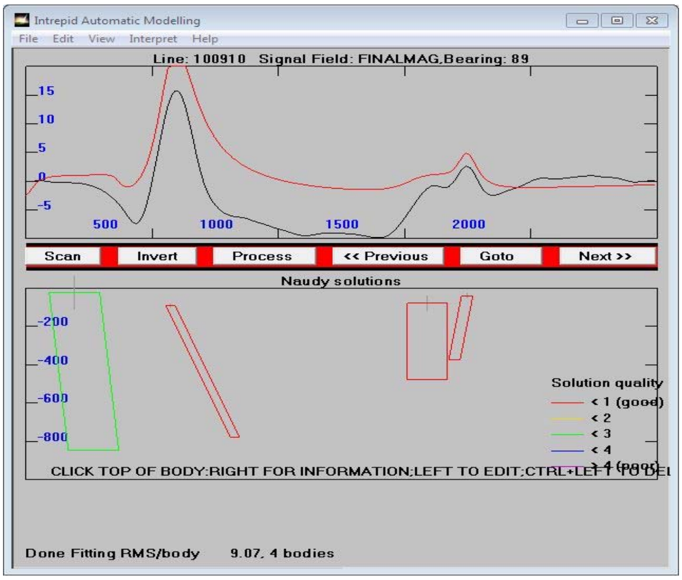


If you wish to specify advanced options, use the **Advanced Model Options** dialog box. Choose **Model Parameters** from the **Interpret** menu to display this dialog box. This dialog box is not designed to remain open like the **Model Parameters and Testing** dialog box. You must choose Accept before INTREPID will use your settings.



Naudy solutions display

The following illustration shows a line's Naudy solutions displayed as small squares after scanning and resampling. The horizontal position of the squares indicates their geographic position (corresponding to the line above. Their vertical position indicates the depth of the Naudy solutions (according to the scale on the vertical axis. The size of the squares indicates their similarity coefficient. A large square indicates a low similarity coefficient.



Scanning for Naudy solutions

The following steps assume that you have

- Selected and displayed the line for scanning and

Ignore any inferred geological structures that INTREPID displays for the line before you commence. This process will overwrite them.

>> To scan for Naudy solutions

1 Select the **Interpret->Model Parameters** and specify, width of Naudy operator, depth increment, finer sampling with depth, remove clearance, body type (Dykes, Steps, Intrasediments), Dip search strategy and body strike options (calculate trends for regularly spaced lines) in the **Advanced Model Options** dialog .

2 Select **Interpret->Sensitivity Test Parameters** and specify the Start and Finish depth and the maximum allowed Absolute Susceptibility in the **Model Parameters and Testing** dialog box

3 Choose Scan. INTREPID will calculate and display the Naudy solutions.

Starting depth / Finishing at depth Use these to specify the depth range for finding and reporting Naudy solutions. INTREPID will not calculate solutions outside this range.

Restrict Maximum Absolute Susceptibility Use this parameter to limit the range of predicted absolute susceptibility

Width of Naudy operator as a multiple of depth *(Advanced option)* INTREPID uses a variable number of data points for calculating solutions, depending on the depth of the solution. The number of data points used is a multiple of the depth of the solution. This parameter specifies the factor for the number of data points used for each depth. The default value is 2. If the Naudy operator is too wide, INTREPID may inadvertently introduce part of a neighbouring anomaly into the calculation. If it is too narrow, INTREPID may only examine the peak of an anomaly and fail to obtain information about its true shape.

Increase successive depths by a factor of (Depth increment) *(Advanced option)* Use this to specify the depth increment factor (dif). INTREPID divides the depth range into sections according to the depth increment factor. The depth section closest to the surface has a height equal to start depth x dif. The height of the next depth section is dif times that of the section above. Deeper sections, therefore, are larger than shallower ones. INTREPID records the depth of a Naudy solution as the depth of the section to which it belongs.

Specifying constant body strike *(Advanced option)* You can specify a constant body strike for inferred geological structures that may result from the Naudy solutions. The default body strike is perpendicular to the line direction.

For Naudy solutions used to calculate inferred geological structures, INTREPID will save this data in the Naudy model point dataset as field **`Strike`**.

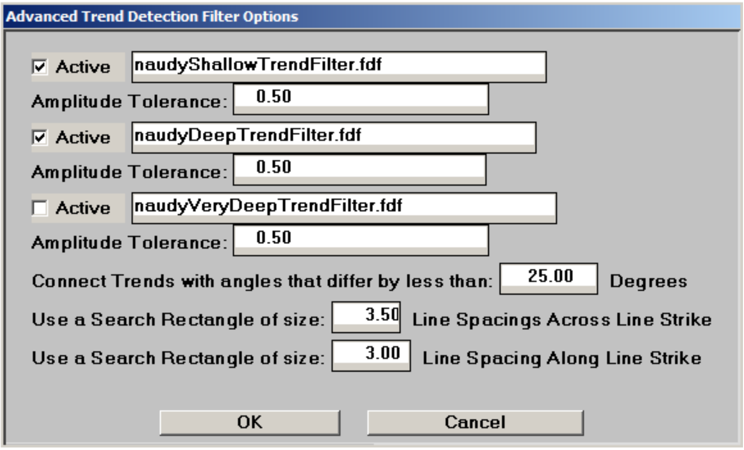
At the formal processing stage, if you have regularly spaced lines and you select the Calculate Trends option then individual body strikes will be estimated using the trend data. These strike estimates will be writtne to the **`Strike`** field. See Specifying body strike for the Naudy model point dataset for details.

—**Use a fixed body strike of** Use this to specify a fixed strike for inferred geological structures. 0 represents North and positive values represent clockwise rotation (e.g., 90 represents East).

—**Set bodies perpendicular to the line** Use this check box to specify the strike for inferred geological structures as perpendicular to the line direction. This will override any existing Fixed Body Strike setting.

—**Calculate Trends** (requires evenly spaced parallel lines) Use this option to derive trends from your input data field that can be used to infer the body strike.

—**Edit Trend Filters** Clicking on this button opens the following dialog box with options for controlling the estimation of trends for your input data field.



Resampling the Naudy solutions

The following steps assume that you have

- Selected and displayed a line,
- Scanned it for Naudy solutions and
- Displayed the **Model Parameters and Testing** dialog box.

>> *To resample Naudy solutions*

1 Specify the similarity coefficient and intensity thresholds for rejecting inferior solutions.

2 If required, specify the advanced options, Width of Naudy operator, Depth Bias factor and Finer Sampling with Depth option.

3 Choose Resample. INTREPID will resample the collection of Naudy solutions, rejecting those with similarity coefficient above the threshold and selecting the best solution in each solution region.

Naudy threshold greater than (Similarity coefficient threshold) INTREPID will reject Naudy solutions with similarity coefficients above the level that you specify here.

TMI anomaly less than (Intensity threshold) Use this to specify the minimum amplitude (in nT) of anomalies to include in the calculation.

Thin solutions using depth factors of (Depth distance factors) *(Advanced option)* INTREPID examines a region surrounding each solution. If the region contains one or more other solutions, INTREPID retains the solution with the lowest similarity coefficient and rejects the others. The Naudy operator width and Depth distance factors determine the size of the region examined around each solution.

This thinning option is no longer available to the user. The thinning operation is now applied automatically using sensible defaults of 0.5 and 0.5 (half the depth sample interval and half the body separation

Creating the model: inferred structures and initial calculated field

After you have calculated and resampled the Naudy solutions, INTREPID can calculate the model and display the corresponding inferred geological structures. It will also display the calculated field for the structures as a red curve superimposed on the black original (observed) line profile.

INTREPID will perform the model calculation according to the parameters you have set in both the Automatic Modelling Options and Testing and Advanced Options dialog boxes. If you have turned on either of the Always Invert options, INTREPID will automatically refine the model after creating it. See Refining inferred structures and optimising the calculated field for details about the refinement process. See Search complexity and refinement options for details about the Always Invert options.

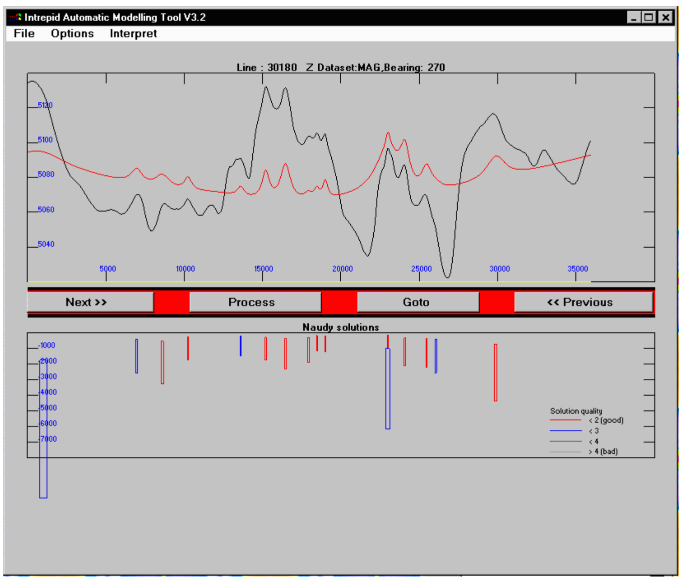
The following step assumes you have scanned for Naudy solutions and resampled them and that the Automatic Modelling Options and Testing dialog box is open.

>> To calculate the model and display the inferred geological structures

1 Specify the line spacing for the model.

2 Choose Create the Model.

INTREPID will calculate and display the inferred geological structures. It will also display the calculated field in red superimposed on the black observed field profile. Depending on the search complexity and refinement options, it may also refine the model. The following illustration shows a model calculated with all of these options turned off.



Assuming a line spacing of Use this to specify the line spacing of the input line dataset in metres. INTREPID will set the length of the inferred geological structures (the dimension perpendicular to the line direction viewed from above) equal to this value and record the length in the **D** field of the Naudy model point dataset. See Illustration of length and body strike for a diagram showing inferred geological structure length.

Refining inferred structures and optimising the calculated field

After INTREPID has calculated the inferred geological structures, it can refine them by modifying their

- Width (parallel to the line direction),
- Depth,
- Horizontal position
- Dip and / or
- Susceptibility.

The goal of the refinement process is to arrive at a set of inferred geological structures whose calculated field most closely matches the observed field along the line.

The refinement process is 'self-conditioning'. Its effectiveness improves within a single set of iterations. Thus one set of 20 iterations is more effective than two sets of 10.

You can perform the refinement process more than once if required. Increase the maximum number of iterations if you find that repeated refinement is necessary

The Automatically Invert option (Advanced Model Options)

If you select the Automatically Invert check box in the Model Parameters->Advanced Options dialog box, INTREPID will automatically refine models as part of the creation process.

The Automatically Invert option is equivalent to Refine the Model in the Automatic Modelling Options and Testing dialog box. In this case you will not normally need to perform the steps described below. If you do choose Refine the Model with Automatically turned on, INTREPID will perform another set of refinement iterations.

INTREPID will automatically cease iterations if it is failing to improve the fit of the calculated field.

See Search complexity and refinement options for details about the Automatically Invert check boxes

Refining the model

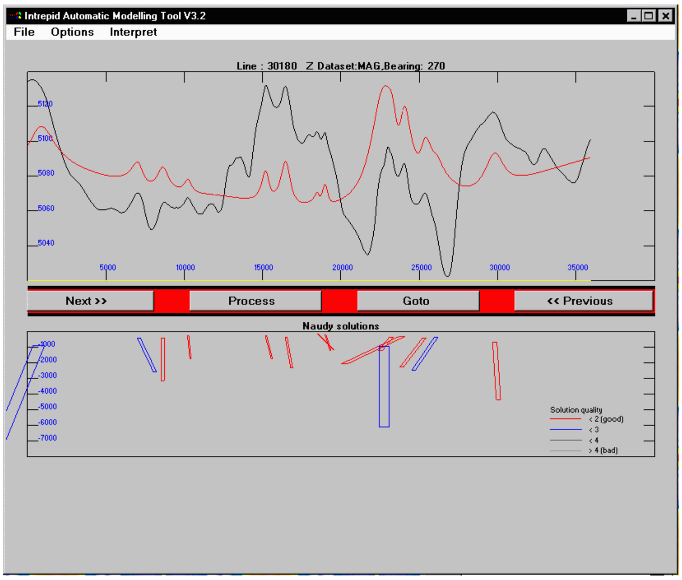
>> To refine the inferred geological structures and optimise the calculated field for the current line

The following steps assume that you have displayed the Model Parameters and Testing dialog box, scanned for Naudy solutions and resampled them, then created the model, displaying the inferred geological structures, and that the Automatically Invert option is turned off in the Advanced Options dialog box.

1 Specify the number of inversion iterations.

2 Choose Refine the Model.

INTREPID will refine the inferred geological structures for the current line, then display them and the refined calculated field.



Up to ___ inversion iterations This parameter specifies the maximum number of refinement iterations INTREPID will perform in a refinement operation. If this parameter is too low, you may not obtain the optimum fit for the calculated field. If the parameter is too high, the process may take additional time without benefit.

Specifying body strike for the Naudy model point dataset

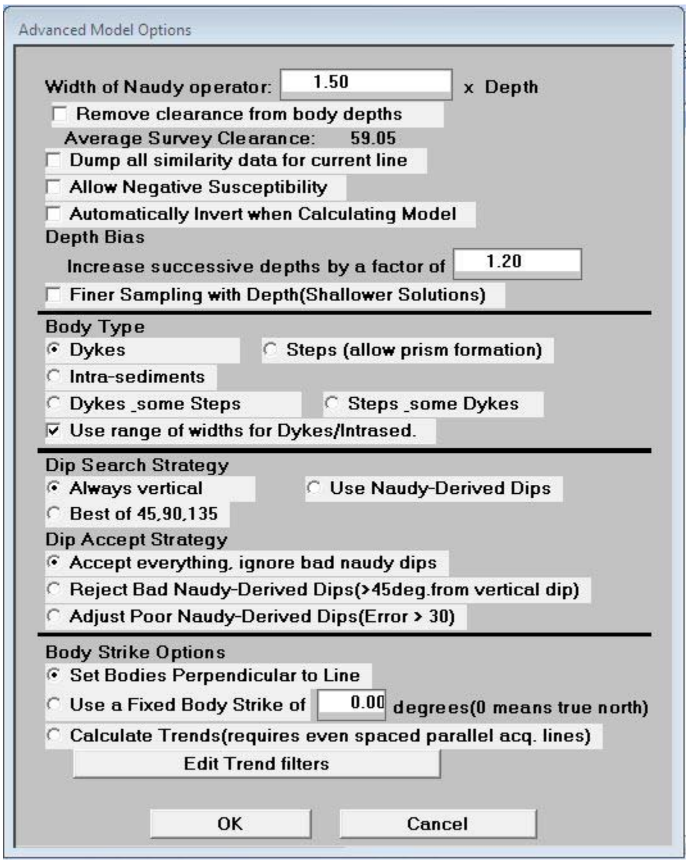
When you create the model, you can specify a constant body strike for all inferred geological structures. See 'Specifying constant body strike' in Scanning for Naudy solutions for details.

INTREPID can include individual body strike data for each inferred geological structure.

You can obtain body strike information by turning on the **Calculate Trends** option in the **Advanced Model Options** dialog.

If you specify Calculate Trends, INTREPID will adjust the values in the `Strike` field of the Naudy model point dataset to incorporate this data.

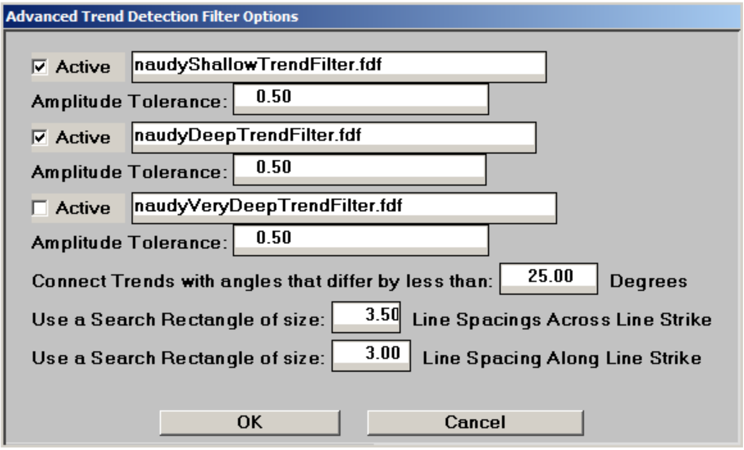
1 Choose Model Parameters from the Interpret menu. INTREPID displays the Advanced Model Options dialog box.



Turn on Calculate Trends and specify the trend filters, the Connect Trend angles limit in degrees and the Search Rectangle sizes for the across and along line trend search in the **Advanced Trend Detection Filter Options** dialog box shown below. This option relies on designing a series of 1D filters to create high pass “bumps” in the profiles, that can be matched between lines, thereby estimating local strike of the geology. The deeper strucural trends are allowed to be different to the surface trends, via a similar 1D filtering strategy.

This approach overcomes one of the main limitations to automation of the Naudy algorithm, when dealing with TMI data, that is the error in depth and body shapes when there is a strike error. Other implimentations tend to apply a strike correction after the body is found, assuming a body normal to the profile. With this implimentation, all the complications of a post-fix go away.

Of course, in the tensor case, a strike is directly implied in the ratio of the 2 invariants of the tensor signal. The zero eigenvector for a 2D body lies in the strike direction.



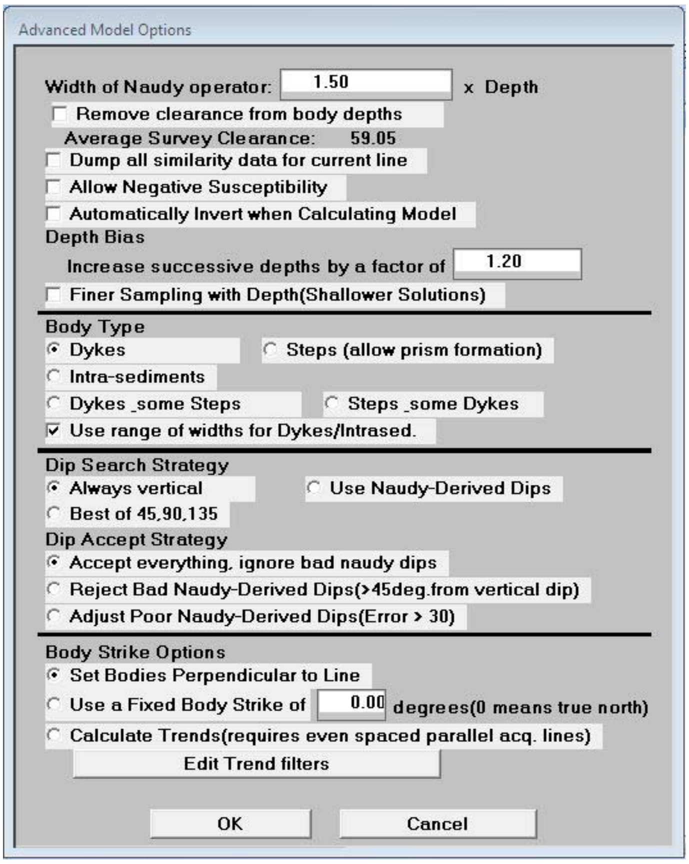
Search complexity and refinement options

You can specify the search complexity and whether to always refine the data. INTREPID will always use these settings when it calculates the model, i.e., when you

- Choose Create the Model in the Model Parameters and Testing dialog box;
- Display a line for which no model exists;
- Process your selection of lines formally (using the Process button).

>> To specify the complexity and extent of the calculation and refinement process.

1 Choose Advanced Options from the Interpret menu. INTREPID displays the Advanced Options dialog box which contains the search complexity and refinement options.



Turn on the check boxes according to your requirements, then choose Accept.

2 If you turn on the Automatically Invert option:

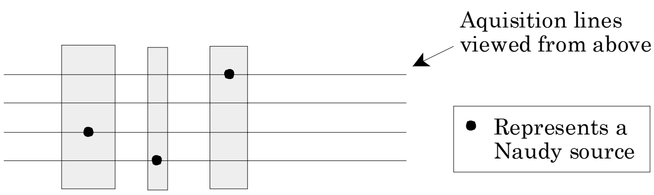
- INTREPID will be automatically refining the model whenever you create a model for a line.

Specify the required number of inversion iterations in the corresponding text box next to the **Opt. Refine the Model** button in the **Model Parameters and Testing** dialog box. See Refining inferred structures and optimising the calculated field for details about this parameter.

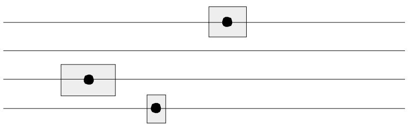
Illustration of length and body strike

The following illustration shows the effect of the line spacing and the body strike data on the inferred geological structures. You are asked to specify the line spacing as a parameter.

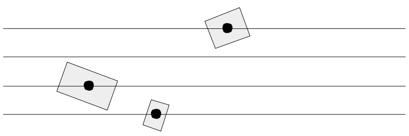
Length and strike of inferred geological structures



Before INTREPID calculates the length, the inferred geological structures have infinite length.



INTREPID assigns a length equal to the dataset line spacing before saving the model solutions point dataset.



If you specify and enable a spline gridding sample points dataset INTREPID assigns a strike to each structure before saving the model solutions point dataset.

Calculating the model for all or part of the dataset

After you have specified the Naudy Automatic Model process you can apply it to some or all lines in the dataset.

You can calculate and refine the model for a list of lines, a range of lines, a single line or all lines.

INTREPID automatically saves the model values in a temporary output dataset. The user must select **File->Save Model As** to save his own set of output models.

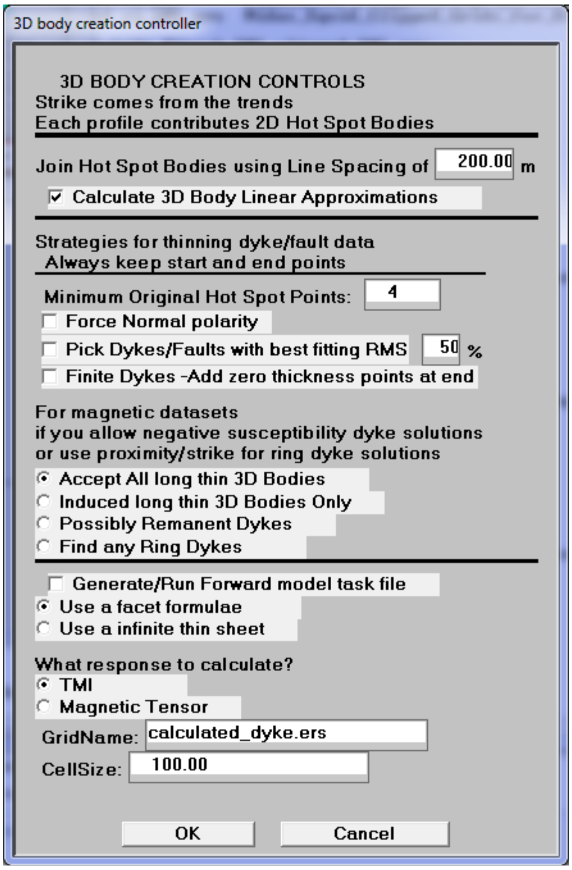
3D Dyke Geometry

The option uder the File menu to export the final emsemble, to Geomodeller format, produces, after a clustering of the soltuions, an ordered list of HOT_SPOT bodies in a csv file, with each identified 3D dykes's points sorted into a following order, with a newly created TAG eg DYKE1, 2 etc. Geomodeller's implicit geology modelling algorithms are clever enough to then turn these foliation observations, into 3D surfaces that are either finite, or continue right across the project.

The Tutorial K exercise distributed with Geomodeller, illustrates this functionality.

There is obviously enough information contained in this automatic interpretation of magnetic survey data, to accomplish a good starting point in any 3D geology modelling environment, if Geomodeller can manage the task. This represents a very big boost in productivity for the geoscientist. The Naudy depth cookbook also contains

comments on this aspect.



The clustering algorithm developed here, joins HOT_SPOT solutions in a recursive search for “WORMS”. There is a comprehensive report in the log file, as to how many simple bodies there are to begin with, and how the joining has managed to reduce the candidate 3D dykes to a more manageable set. The use of the inversion RMS measure to further cull HOT-SPOT solutions from each 3D worm, means that you are not over-specifying foliation data along the dyke, while still capturing its variable width and susceptibility estimates.

You can bias the search to the more linear of features, or, the other way, to favour ring dykes.

You can choose the option to allow you to add pinch-out points at the end of dykes that might fade within the project boundary, thus allowing you to create a 3D model with dykes having limited extents.

At the bottom of this dialog, there is the options for calculating a geophysical grid with the newly sorted “WORM” bodies. The option of using the infinetly thin body formulatioin, which is then post multiplied by a dyke thickness, or a slower 3D facet model of the worms, is given. What is happening behind the scenes, is the creation of a V5.0 protbuf message, passing the DYKE geometry and properties to the MTdyke tool, to do the required job.

This gives you a quick ability to see how much of the observed signal has been captured by the DYKE model.

Worm Formation Log

The following is a sample report extracted from the *naudy_depths.log* file that is

created automatically during this process. We have annotated the report as an aid to helping you to interpret the process.

```
Actual Number of Simple Bodies used for worms 329   ORIGINAL Naudy solution count
Initial Worm count = 105                             First go at forming WORMS
3D Body Data  from naudyd to File OriginalWorms.csv,  Original Worm count = 105, Export to Geomodeller Worms
0, Total simple bodies used 0
Conditioned, sorted worm step 17 duplicate bodies, 1 out of order, 0 strike issues, 0 dip issues
3D Body Data  from naudyd to File joiningWorms1.csv,  Original Worm count = 91, Export to Geomodeller Worms
28, Total simple bodies used 105
Conditioned, sorted worm step 25 duplicate bodies, 0 out of order, 0 strike issues, 0 dip issues
3D Body Data  from naudyd to File joiningWorms2.csv,  Original Worm count = 87, Export to Geomodeller Worms
25, Total simple bodies used 85
Conditioned, sorted worm step 7 duplicate bodies, 1 out of order, 0 strike issues, 0 dip issues
3D Body Data  from naudyd to File joiningWorms3.csv,  Original Worm count = 84, Export to Geomodeller Worms
25, Total simple bodies used 95
Conditioned, sorted worm step 7 duplicate bodies, 0 out of order, 0 strike issues, 0 dip issues
3D Body Data  from naudyd to File joiningWorms4.csv,  Original Worm count = 82, Export to Geomodeller Worms
26, Total simple bodies used 101
Conditioned, sorted worm step 12 duplicate bodies, 0 out of order, 0 strike issues, 0 dip issues
3D Body Data  from naudyd to File joiningWorms5.csv,  Original Worm count = 79, Export to Geomodeller Worms
26, Total simple bodies used 99
Conditioned, sorted worm step 7 duplicate bodies, 0 out of order, 0 strike issues, 0 dip issues
Final Worm count = 79          After a recursive joining process, number of WORMS
Lines with unknown strike = 0
Box tests = 85589, angle tests 378, proximity tests 349, Join Worm Recursive level 5
Conditioned, sorted worm step 6 duplicate bodies, 0 out of order, 0 strike issues, 0 dip issues
Linearization Summary
 Dyke      nPts Strike Dip Length Thickness Linear_deviation RMS_ERROR  Susceptibility Similarity  startX
sY        endX        eY
Dyke1,    4,  142,   80,     164.3,     37.39,       5.0,       0.7,     0.00291,    1.0,    531844.31,
7410115.06, 531743.70, 7410244.94
Dyke2,   17,  128,   76,     818.4,     43.89,       8.9,      25.7,     0.03926,    1.1,    531967.40,
7410554.50, 531324.06, 7411060.33
Dyke3,    6,  144,   68,     338.9,     37.66,       8.0,       7.8,     0.01460,    0.9,    531659.58,
7410075.37, 531465.14, 7410352.89
Dyke4,    4,  102,   71,     147.3,     51.46,      10.2,       0.6,     0.00207,    1.4,    532252.90,
7411351.51, 532109.05, 7411383.44
Dyke5,   16,  133,   78,     775.1,     42.67,       8.7,      31.3,     0.04236,    0.7,    531333.02,
7410258.57, 530769.80, 7410791.05
Dyke6,    6,  129,   77,     258.5,     55.84,      11.0,      33.9,     0.04088,    1.1,    531298.11,
7410571.88, 531099.53, 7410737.36
Dyke7,   15,  131,   72,     758.4,     52.25,      15.2,      11.3,     0.02641,    1.1,    531061.91,
7410354.83, 530492.76, 7410856.13
Dyke8,    4,  148,   82,     137.4,     70.19,       9.3,      29.6,     0.06061,    1.3,    531064.73,
7410781.03, 530993.60, 7410898.54
Dyke9,    4,  125,   57,     141.1,     51.16,      15.0,       1.1,     0.00196,    1.2,    531615.26,
7411761.93, 531501.02, 7411844.68
Dyke10,    8,  124,   81,     342.5,     77.03,       7.9,      20.8,     0.04587,    1.3,    530960.20,
7410889.42, 530678.48, 7411084.26
Dyke11,    4,  134,   65,     151.5,     57.80,       0.2,      10.9,     0.02639,    1.6,    530906.49,
7410902.06, 530797.97, 7411007.73
Dyke12,    5,  105,   61,     149.0,     38.92,       9.2,      10.2,     0.00738,    1.6,    531125.42,
7411243.33, 530981.47, 7411281.96
Dyke13,    6,  136,   82,     470.2,     53.92,       6.9,       5.4,     0.03324,    1.1,    530873.38,
7410934.86, 530547.15, 7411273.42
Dyke14,    5,  102,   72,     467.0,     55.26,       6.7,       1.6,     0.00434,    1.6,    531336.44,
7411548.72, 530879.80, 7411646.58
Dyke15,    8,  146,   70,     432.1,     43.47,      15.7,       6.3,     0.01271,    1.0,    530896.43,
7411288.80, 530658.46, 7411649.51
Dyke16,    8,  142,   80,     299.7,     47.83,      10.2,       8.0,     0.00901,    1.2,    530544.52,
7410983.14, 530362.99, 7411221.66
Dyke17,    4,  119,   77,     147.9,     34.51,       8.1,       2.9,     0.00512,    0.9,    530764.82,
7411453.30, 530635.65, 7411525.41
Dyke18,    5,  131,   64,     197.6,     44.76,       3.1,       4.7,     0.01340,    0.9,    530503.68,
7411334.13, 530355.70, 7411465.11
Dyke19,    7,  121,   53,     276.5,     42.10,       7.4,       0.9,     0.00208,    1.7,    530976.94,
7412246.62, 530740.30, 7412389.68
Dyke20,    4,   35,   64,     266.2,     57.78,       2.7,       2.7,     0.00391,    1.5,    530341.70,
7411441.79, 530496.82, 7411658.16
Dyke21,    7,  118,   78,     279.6,     76.74,      10.3,       5.2,     0.02023,    1.2,    530355.06,
7411526.37, 530108.75, 7411658.71
Dyke22,    5,  138,   66,     195.9,     41.38,       6.9,       1.2,     0.00224,    1.6,    530337.95,
7411746.20, 530208.14, 7411892.98
Dyke23,    4,   86,   82,     240.2,     91.81,       8.1,      55.7,     0.04371,    1.3,    530129.97,
7411665.63, 529890.10, 7411652.58
Dyke24,    4,  122,   73,     144.9,     36.63,       3.6,       7.0,     0.01802,    1.9,    529884.56,
7411240.96, 529761.77, 7411317.82
Dyke25,    7,  133,   70,     313.8,     29.86,       6.5,       1.8,     0.00385,    1.0,    530255.08,
7411953.91, 530027.85, 7412170.29
Dyke26,    4,  123,   75,     140.0,     41.75,       2.2,       1.9,     0.00531,    1.0,    530148.40,
7412185.71, 530031.03, 7412262.10
Geomodeller minimum number hot spots / worm : 4
```

```
3D Body Data  from naudyd to File D:/test_data/FullTests/naudyd_test/mat_basil/eni_d.csv,  Original Worm count
= 79, Export to Geomodeller Worms 26, Total simple bodies used 100
Before thinning - Mean length 6.576923, Max length 17.000000
After  thinning - Mean length 5.730769, Max length 10.000000
Exported 3D body Linear Summary  from naudyd to File D:/test_data/FullTests/naudyd_test/mat_basil/
Summary_eni_d.csv,  Original Worm count = 79, Geomodeller Linear Summary Dykes 26
```

Data created during the model specification

Each time you view a line for which no model exists, INTREPID calculates and refines the currently specified model for it. This line then joins the collection of lines for which the model exists in the temporary file mentioned above.

If you change the specifications for the model and a previously viewed line is then not included in your selection of lines to be processed, it will remain in the Naudy model point dataset even though it may have undesirable or out of date results.

In order to prevent this from happening, use the **Edit-> Clear Model for Current Line** or **Clear Model for All Lines** options before commencing the formal processing of the dataset.

INTREPID will overwrite the model results for any lines that you have previously displayed and are included in your selection of lines to be processed.

Performing the model calculation on the selected lines

>> To perform the model calculation (and refinement process if selected) for specified lines in the dataset

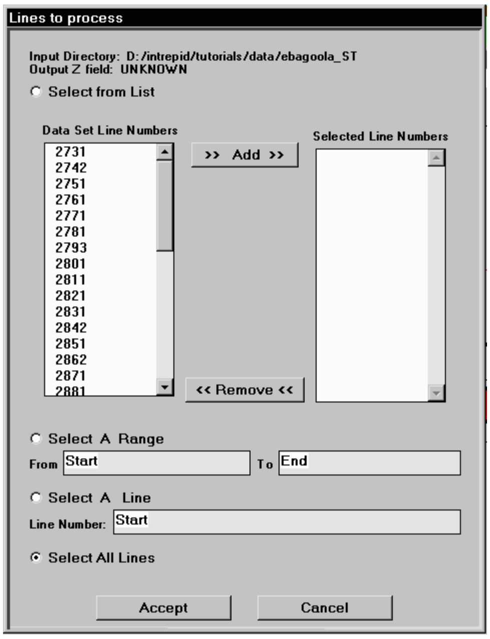
1 Ensure that you have specified according to your requirements

- The model,
- The search complexity and refinement options and
- The calculate trends option is turned on for regularly spaced lines.

2 Save the output models when you have completed your processing using **File->Save Model As**

3 Choose Process from the Naudy Automatic Model window.

INTREPID displays the Lines to Model dialog box.



4 Select the option corresponding to your line selection method.

Select from List, Select a Range, Select a Line, Select All

5 *If you selected Select from List*, move the line numbers between the Dataset Line Numbers and Selected Line Numbers list boxes as required. (The Selected Line Numbers list box shows a list of the lines for processing and the Dataset Line Numbers list box shows a list of lines that are not for processing.)

To move a line number to the other list select (click) it so that it is highlighted, then choose >> Add >> or << Remove <<.

If you selected Select a Range, enter the first and last line numbers to be processed into the corresponding text boxes.

If you selected Select a Line, enter the number of the line required in the corresponding text box.

Note: For Select a Range and Select a Line you can enter line numbers or the words **`start`** and **end** which signify the first and last line numbers.

6 When you have specified the lines for processing, choose Accept.

7 INTREPID will process the dataset as specified.

Saving the current model results

- As INTREPID performs model calculations it saves them to a temporary points dataset.
- During or after the model specification and testing process you can save the currently displayed line's model to your own points dataset.

Saving the model as a point dataset

>> To save the output dataset

Use Save Model As from the File menu as required.

Exit

To exit from Naudy Automatic Model choose Quit from the File menu.

Structure of Naudy model point datasets

Each data point on a Naudy model point dataset represents an inferred geological structure.

Naudy model point datasets have the following fields

Field (new)	Field (old)	Description
`Width`	`A`	Width of inferred geological structure in the line direction (before the body strike is changed by trend calculation).
`Dip`	`B (or D)`	Dip of inferred geological structure (rotation about axis perpendicular to the line direction).
`DepthExtent`	`C`	Height (depth extent) of inferred geological structure.
`Length`	`D (or B)`	Length of inferred geological structure perpendicular to the line direction (before the body strike is changed by trend calculation).
`BodyType`	`BodyType`	Code indicating whether inferred geological structure is a dyke or a step.
`Susceptibility`	`Ka`	Magnetic susceptibility of inferred geological structure.
`Similarity`	`Similarity`	Similarity coefficient of inferred geological structure.
`Strike`	`Strike`	Absolute strike of inferred geological structure (0 = North) INTREPID initially obtains this from the line direction but may modify it during trend calculation.
`Depth`	`Z`	Depth estimate for inferred geological structure.
`Depth_Bin_No`	(new)	Naudy Automatic Model classifies solutions into groups (bins) by depth. This field contains the bin number of the current inferred geological structure.
`Depth_of_Bin`	(new)	Depth of the bin (group) to which the current inferred geological structure belongs.
`groupID`	(new)	Field for use by users for their own purpose (intended for manually classifying inferred geological structures into groups)
`X`	`X`	East–West geographic location
`Y`	`Y`	North–South geographic location
`LineIndex`	`Line`	Line number of line from which INTREPID derived the inferred geological structure.
`LineBearing`	(new)	Average bearing of line from which INTREPID derived the inferred geological structure, calculated Naudy Automatic Model tool.
`LineDp`	(new)	Interpolation increment along line from which INTREPID derived the inferred geological structure.

Field (new)	Field (old)	Description
LineNPoints	(new)	Number of interpolated points in line from which INTREPID derived the inferred geological structure.
LineX0	(new)	Coordinates of first point in line from which INTREPID derived the inferred geological structure.
LineY0	(new)	
Haz	**RemAz**	Declination of inferred geological structure's remanent magnetic field. All inferred geological structures currently have 0 remanent fields.
H	**RemH**	Intensity of inferred geological structure's remanent magnetic field. All inferred geological structures currently have 0 remanent fields.
Hinc	**RemInc**	Inclination of inferred geological structure's remanent magnetic field. All inferred geological structures currently have 0 remanent fields.
MC_Length	**MC_Length**	Scaled version of field **Length** for use in hard copy composition (being phased out).
MC_Slope	**MC_Slope**	Scaled version of field **Dip** for use in hard copy composition (being phased out).
MC_Width	**MC_Width**	Scaled version of field **Width** for use in hard copy composition (being phased out).
(no longer in use)	**Plunge**	Plunge of inferred geological structure (rotation about axis in the line direction). All inferred geological structures currently have Plunge = 0.
(no longer in use)	**Isotropy**	**Isotropy** = 1 if the magnetic susceptibility of the inferred geological structure is direction independent (all INTREPID solutions data currently has this value).
(no longer in use)	**Density**	(not in use)
(no longer in use)	**Dip**	(not in use)
(no longer in use)	**Kb**	(not in use)
RMS_ERROR	**-**	The misfit of the calculated body to the observed signal, as estimated during an inversion stage, is now also reported.

Displaying options and using task specification files

Displaying options

See Querying lines and setting resampling options for information about displaying the pre-model settings for the current line.

See Specifying the modelling process for information about displaying the model calculation and refinement specifications.

Using task specification files

You can store sets of file specifications and parameter settings for Naudy Automatic Model in task specification (**.job (OLD), or .task (NEW)**) files.

>> To create a task specification file with the Naudy Automatic Model tool

1. Specify all files and parameters.
2. If possible, execute the task (choose Apply) to ensure that it will work.
3. Choose Save Options from the File menu. Specify a task specification file (INTREPID will add the extension **.job**) INTREPID will create the file with the settings current at the time of the Save Options operation.

For full instructions on creating and editing task specification files see INTREPID task specification (`.job`) files (R06). With V5.0 Intrepid, we have introduced the GOOGLE protobuf language as a means of specifying all the data procesisng options for all tools in Intrepid and Geomodeller. This has then also been published, and you can find the "Intrepid_tools.proto" file with any installed version of Intrepid. Within this file, a formal definition and lexicon for the options available within this Naudy tool are given. One of the big advantages gained by this development, is the unambiguous specification and the rigourous parser and checking of the task files, together with explicit error reporting, when you get it wrong.

>> To use a task specification file in an interactive Naudy Automatic Model session

1. Load the task specification (**.job, or .task**) file (File menu, Load Options).
2. Modify settings as required.
3. Choose Process. See Calculating the model for all or part of the dataset for instructions.
4. Save the Naudy model point dataset if required. See Saving the model as a point dataset for instructions.

>> To use a task specification file for a batch mode Naudy Automatic Model task

Type the command **naudyd.exe** with the switch **–batch** followed by the name (and path if necessary) of the task specification file.

For example, if you had a task specification file called **surv329.job** in the current directory you would use the command

```
naudyd.exe –batch surv329.job ( old syntax)
naudyd.exe –batch surv329.task ( new syntax)
```

Task specification file notes and example

Here is an example of a Naudy Automatic Model task specification file.

```
# Example task file V5.0 protbuf syntax - naudy
#  manual or automatic
#  outputs, combine all the by line solutions into a coherent
“worm dyke” for use in Geomodeller
# Usage: fmanager -batch ebagoola_geomodeller_export.task

IntrepidTask {
      Naudy {
      InputLines: “../datasets/ebagoola_S..DIR”;
      InputSignal: “../datasets/ebagoola_S..DIR/smooth_mag”;
#     InputClearance: “../datasets/ebagoola_S..DIR/radAlt”;
      OutputNaudyModel: “../datasets/ebagoola_nau1..DIR”;
      ReportFile: “ebagoola_geomodeller.rpt”;
      MagneticField {
            Magnitude: 56959.39;
            Declination: 6.25;
            Inclination: -62.5;
            SurveyYear: 2004;
            SurveyMonth: 1;
            SurveyDay: 1;
      }
      processType: ALL_LINES;  # do full survey
      SampleMode: XY_BASED; # treat spatially
      VerticalDerivative: false;  # use the TMI
      AutoIGRF: true;   # turn on for
      StartDepth: 70.0;  # No bodies in the air gap
      EndDepth: 2000.0;
      WindowFactor: 1.5;
      MinAmplitudeCutoff: 1.0;  # 1 nT noise floor
      MaxAmplitudeCutoff: 100.0;  # highest anomaly to consider
      LineSpacing: 400.0;
      DipRange: false;  # just start with vertical
      WidthRange: false;  # just one aspect ratio of width to depth
      UseDerivedDip: true;  # use the estimated dip
      UseFinerVerticalSampling: false;  #
      allowNegativeSusc: false;
      AlwaysInvert: false;
      CullOnNaudyDip: true;
      FixOnNaudyDip: true;
      DumpSimilarity: false;
      ForceOntoProfile: false;
      MaxInvertIterations: 5;
      MaximumBodySimilarityToKeep: 3.0;  # keep better solutions
with similarity less than 3
      RemoveClearance: true;
      BodyType: Dyke;  # look for dykes
      Geomodeller_minimum_number_hot_spots: 4;
      Create3D_DykeLinears: true;
      Trends {
            StrikeCode: ST_CALC;  # estimate the strikes/trends
```

```
within the survey
          ShallowFilter: “naudyShallowTrendFilter.fdf”;
          DeepFilter: “naudyDeepTrendFilter.fdf”;
          VeryDeepFilter: “naudyVeryDeepTrendFilter.fdf”;
          ShallowTolerance: 2.0;
          DeepTolerance: 5.0;
          VeryDeepTolerance: 0.5;
          AlongLine: 3.0;
          AcrossLine: 3.5;
     }
     Worms {
          OutputGeomodeller: “ebagoola_dykes.csv”;
          Geomodeller_minimum_number_hot_spots: 4;
          CreateDykeLinears: true;
          RequiredMagnetization_Worms: MAG_ALL;
          MakeFiniteDykes: true;
          CullReversePolarity: true;   # make sure the right hand
rule is being applied
          BestFitting: true;
          BestFittingPercent: 50;  # just take best fitting
solutions, 50% of them
          }
}}
```

The older, V4 syntax, but still support for now,is shown following -

```
Process Begin
   Name = naudyd
   Parameters Begin
      LineIO Begin
         InputLines = "/disk1/survey/ebagoola"
      LineIO End
      NaudyOptions Begin
         InducingFieldIntensity = 41036.9029453278
         InducingFieldAzimuth = 0.64450229434569
         InducingFieldInclination = 28.277338372818
         AutoIGRF = 1
         StartDepth = 50.0
         EndDepth = 30000.0
         DepthIncrement = 1.1
         AmplitudeCutoff = 2.0
         BodyStrike = 0.0
         AutoStrike = 1
         BinSizeX = 0.5
         BinSizeZ = 0.5
         LineSpacing = 200.0
         TrendCellSize = 70.0
         Complexity = 0
         AutoStrikeOut = 1
         MaxInvertIterations = 10
         Threshold = 3.0
         BodyCode = "BT_DYKE"
      NaudyOptions End
```

```
                WormOptions Start
                     Geomodeller_minimum_number_hot_spots = 4
                     CreateDykeLinears = 1
                     RequiredMagnetization_Worms = MAG_ALL
                     MakeFiniteDykes = 1
                     CullReversePolarity = 1
                     BestFitting = 1
                     BestFittingPercent = 50
                WormOptions End
                 ProcessParameters Begin
                    Process = "ALL_LINES"
                    StartLineNumber = 0
                    EndLineNumber = 0
                    NoOfLines = 0
                    SampleMode = "XY_BASED"
                 ProcessParameters End
              Parameters End
           Process End
```

Here is a more fully annotated version-

```
##  more annotated job file showing all options, with most of the enumerates
Process Begin
      Name  = naudyd
      OutputNaudyModel= data/nau1..DIR
      OutputWorms= data/worm1..DIR
      OutputTrends= data/trend1..DIR
      InputLines= raw/TeisaDsubset1..DIR
      InputZ= raw/TeisaDsubset1..DIR/MagFinal
      #InputModel= data/nau1..DIR   ##  can update an existing model
      #InputTrends= data/trend1..DIR  ## can use existing trends database
      Parameters Begin
            Field Begin
                  InducingFieldIntensity= 51649.9080802049
                  InducingFieldAzimuth= 3.8918163236731
                  InducingFieldInclination= -51.896640692569
            Field End
            NaudyOptions Begin
                  AutoIGRF= 1
                  VerticalDerivative = 0
                  StartDepth= 70.0
                  EndDepth= 2000.0
                  WindowFactor= 1.5
                  MinAmplitudeCutoff= 0.0
                  MaxAmplitudeCutoff= 100.0
                  BodyStrike= 0.0
                  LineSpacing= 200.0
                  DipRange= 0
                  WidthRange= 0
                  UseDerivedDip= 1
## if trying to dip match more exactly at the surface for a BIF
                  naudyUseFinerSampling= 0
## now for model body types
                  UseStep= 0
```

```
                UseString= 0
                UseDyke= 1
# options for admisable bodies
                allowNegativeSusc= 0
                AlwaysInvert= 1
                CullOnNaudyDip= 1
                FixOnNaudyDip= 1
                DumpSimilarity= 1
##  solver assumes a vertical section, so XY coords not alwys on a real profile
                ForceOntoProfile = 1
                MaxInvertIterations= 5
                Threshold= 3.0
#  BT_DYKE, BT_SLAB
                BodyCode= “BT_DYKE”
           NaudyOptions End
           WormOptions Start
                Geomodeller_minimum_number_hot_spots = 4
                CreateDykeLinears = 1
                RequiredMagnetization_Worms = MAG_ALL
                MakeFiniteDykes = 1
                CullReversePolarity = 1   # make sure the right hand rule is
being applied
                BestFitting = 1
                BestFittingPercent = 50  # just take best fitting solutions,
50% of them
           WormOptions End

           Trends Begin
## ST_PERPENDICULAR, ST_USER, ST_TRENDS, ST_CALC
                StrikeCode= “ST_CALC”
                ShallowFilter = “naudyShallowTrendFilter.fdf”
                #ShallowFilter = “naudyDeepTrendFilter.fdf”
                DeepFilter = “naudyDeepTrendFilter.fdf”
                #VeryDeepFilter = “naudyVeryDeepTrendFilter.fdf”
                ShallowTolerance = 2.
                DeepTolerance = 5.
                #VeryDeepTolerance = 5.
                Rectangle Begin
                     AlongLine = 3.0
                     AcrossLine = 3.5
                Rectangle End
           Trends End
           ProcessParameters Begin
##  ALL_LINES, SINGLE_LINE, LINE_RANGE, LINE_SELECTION
                Process= “ALL_LINES”
                #StartLineNumber= 7754400
                #EndLineNumber= 776200
                #NoOfLines= 20
#  XY_BASED, FID_BASED, FIXED_MODE
                SampleMode= “XY_BASED”
           ProcessParameters End
      Parameters End
Process End
```